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# A STUDY OF THE LEAD DEPOSITS IN THE SOUTHWESTERN UNITED STATES WITH NOTES ON EXPLORATION POSSIBILITIES

L. P. Entwistle February, 1963

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

February 21, 1963

Mr. C. P. Pollock, Exploration Manager
American Smelting and Refining Company
120 Broadway
New York 5, New York

LEAD DEPOSITS IN THE
SOUTHWESTERN UNITED STATES

Dear Sir:

This will transmit Mr. Entwistle's final report on his investigation of sources of lead for the El Paso smelter.

This is a comprehensive report and was preceded by thorough review of all literature and our voluminous files, and a considerable amount of field investigation.

Mr. Entwistle recognizes a number of exploration possibilities in various districts; however, all of these are long range at best, and most of them are in the wild-cat category. None of them could be expected to improve materially the lead supply for El Paso.

A few of the occurrences possibly deserve more attention if the demand for lead improves. We will keep these situations in mind and will do more work on then when convenient. Otherwise, we feel that the project is completed.

Mr. Entwistle is to be complimented for having done a thorough job.

Yours very truly,

Kenyon Richard

KENYON RICHARD

KR/kw
Attachment
cc: CPPollock, w/ 2 extra atts.
DJPope, w/1 att.
WGRouillard, w/1 att.
BDRoberts, " "
RFWelch, " "

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona
February 15, 1963

MEMORANDUM FOR MR. KENYON RICHARD

LEAD DEPOSITS IN THE
SOUTHWESTERN UNITED STATES

Attached hereto is a general report on the lead deposits in New Mexico, Arizona, and Texas. Pages 3 and 4 summarize the exploration possibilities. All these involve district studies, research, and probably the application of geophysics, but the last cannot be pinpointed until the basic geological work has been completed. Naturally, remarks concerning previous work apply only to the search for lead (and zinc) because many large areas have been studied, especially in recent years, for extensive alteration zones that may reflect disseminated copper mineralization.

Many mines and small districts have had some previous drilling exploration, either by ourselves or by other companies. In some cases, I do not believe that a district should be written off only because some other company has put down a few drill holes. This may serve only to eliminate certain areas. These deposits present such a small target that occasionally drilling has been done by several companies before one finally hits the target. In the Central district within much of the ground now held by the U. S. Smelting Company, the deposits were drilled and/or studied previously by ourselves, American Metals, and Eagle Picher.

The great drawback to any exploration is that the deposits are usually small and require expensive underground extraction methods. Possibly the only exception may be the disseminated galena in the Llano-Burnet region of Texas.

The appendices describe very briefly the conditions, as we now know them, at some of the better known districts where lead deposits have been mined or explored.

L. P. ENTWISTLE

LPE/kw
Attachment

# A STUDY OF THE LEAD DEPOSITS IN THE SOUTHWESTERN UNITED STATES WITH NOTES ON EXPLORATION POSSIBILITIES

By

L. P. Entwistle
February, 1963

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# 1. INTRODUCTION

A study of the lead resources in the Southwest was made during 1962. A number of trips were made, especially into New Mexico and Texas; and the Tucson Office Exploration files, filling 33 drawers, were studied as well as many U.S. Government and State publications.

The review was requested because substantial tonnage of lead concentrates will be lost by the El Paso smelter in the near future. The loss, which is about 80,000 tons annually of concentrates, is roughly equivalent to one or more mines producing at the rate of 6,000 tons per day of 2% lead ore, or 42,000 tons of fine metal per year. The combined production of lead metal from New Mexico, Arizona, and Texas during times of higher prices than the present was only about 33,000 tons of fine metal (see Tabulation 1, p.2). Unless, therefore, some new major deposits -- probably several the size of the best ever known in this area -- are found, the deficit cannot be balanced from mines in this area, even assuming that the entire output would be smelted at El Paso plant.

Lead production has been diminishing because as mines attain greater depth the lead content decreases and the zinc increases, except deposits of Precambrian age. Reasonable exploration opportunities are unlikely, but a number of high risk, wild-cat ventures still seem to be available; however, in most cases, much may depend on greatly improved geophysical techniques.

The geological environment of the lead deposits is discussed and certain long-range exploration possibilities brought out. An appendix describes briefly many of the deposits that have been examined by Asarco engineers and geologists; some of the reports go back 45 years. Only a few district studies have been made; most concern spot examinations and stress ore in sight rather than more general exploration bets.

In essence, no "hot" prospects have been found nor are indicated in the vast amount of data gathered over the years. If any new ore bodies should be found in the areas mentioned herein, they surely could not be ready to solve the El Paso problem.

## Tabulation 1

### Average Annual Production of Lead in Tons of Fine Metal

| | 1961 | 1956-60 | 1951-55 | 1946-50 | 1941-45 |
|---|---|---|---|---|---|
| **New Mexico** | | | | | |
| Grant County | 1019 | 1973 | 2512 | 3370 | 4525 |
| Hidalgo County | 100 | 41 | 95 | 233 | 152 |
| Socorro County | 1190 | 1010 | 1287 | 1781 | 1095 |
| Others | 23 | 32 | 104 | 163 | 30 |
| Total | 2332 | 3056 | 3998 | 5547 | 5802 |
| **Arizona** | | | | | |
| Cochise County | 26 | 86 | 1256 | 12248 | 3584 |
| Gila County | 6 | 13 | 27 | 285 | 498 |
| Graham County | - | 143 | 912 | 954 | 167 |
| Mohave County | - | 80 | 91 | 364 | 1408 |
| Pima County | - | 933 | 1153 | 3337 | 1089 |
| Pinal County | 2 | 98 | 1923 | 5748 | 3488 |
| Santa Cruz County | 985 | 2643 | 2499 | 1812 | 4267 |
| Yavapai County | 4911 | 6994 | 4426 | 3215 | 1536 |
| Yuma County | 5 | 11 | 22 | 148 | 529 |
| Others | 2 | - | - | 17 | 175 |
| Total | 5937 | 11001 | 12309 | 28128 | 16741 |
| **Texas** | | | | | |
| Total | none | none | 20 (1) | 111 | 76 (2) |
| **Average Price of Lead per lb. - New York** | 11.9¢ | 13.4¢ | 15.3¢ | 13.9¢ | 6.4¢ |

(1) Last Production 1952
(2) No Production 1944-45

## 2. EXPLORATION POSSIBILITIES

The search for new lead deposits is confronted with many difficulties. The deposits are, in general, small if compared to something the dimensions of a prophyry copper. A first-order deposit would be between 2 and 5 million tons of ore. Most all the lead deposits have outcropped and have left in the oxidized zone material of economic grade to encourage deeper work, although in many cases due largely to a concentration of precious metals. By continued exploration in operating mines many completely new deposits have been found. The tendency of most lead-bearing deposits, except those of Precambrian age, is for a decrease in lead content and an increase in zinc with depth. The small scattered nature of many of the ore bodies, all of which involve underground mining, has led to high costs and low productivity.

The deposits of Precambrian age have a certain advantage in that they may continue to greater depth with little change in grade and over a long period of time produce a substantial tonnage. The two important mines in this category, the Iron King and the Pecos, were not marked by good ore bodies near the surface. The Pecos was originally promoted as a copper prospect, and the Iron King was acquired in the last 20 years by tax sale. It seems, therefore, that we should give attention to some of the less promising outcrops. Around the Pecos area some preliminary geochemical samples have given anomalous results in the upper part of Cow Creek, about 5 miles south-southeast of the mine. When the snow clears additional work will be required. Probably first more detailed sampling will be done to determine the size of the anomalous area.

Known veins of Laramide age do not appear to hold much hope. They have, in general, been rather well explored, and they tend to become impoverished at shallow depth. Some have been economic only in the enriched zone due to the concentration of precious metals. At the Macho district, however, unconfirmed data suggests that the sedimentary rocks may be within reach by drilling. The old mine produced very little from the vein in volcanic rocks, and wall rock alteration is weak. This may be one of the long-shots worth a try.

The vein at the Reymert mine, Superior district, is wide and long. The ore is essentially silver with low sulfide content and the gangue contains barite and fluorspar. The deepest workings are only 430 feet. The wall rock is Precambrian schist, but the mineralization is probably related to Laramide intrusives and structure.

Search for new limestone replacement bodies may have the best possibilities in the deposits of Laramide age. Here geophysical methods will have to play an important part in order to aid in reducing the target size, but it seems that present techniques will have to be greatly improved, or new ones developed. Depth penetrations are becoming more important and selectivity will have to be greater.

Around the Carbonate Hill mine in the Steins Pass district only the Cretaceous limestones have been explored, yet the favorable Carboniferous strata probably exist in depth. At Cooks Peak a large fault has displaced and buried the favorable horizons 1000 feet. In both of these areas, however, the target may be small.

Some exploration possibilities may still be present around the Ground Hog.

These include exploration of (1) footwall structures where they may penetrate the limestones, and (2) the post-ore structures in Tertiary volcanics where they enter the older rocks (these faults may be only a re-opening of pre-mineral breaks), and (3) more drilling into the Lower Paleozoic dolomites. The ore outlook to the southwest on the Ground Hog structure, that is, towards Lone Mountain, now seems less promising. Elsewhere in the Central district additional studies may be indicated in the hanging wall of the Barringer fault zone in the vicinity of Hermosa Peak where only the Cretaceous sedimentary rocks and intrusives are outcropping.

Geophysical surveys have not been able to assist in tracing the Carboniferous limestones northwest from Lone Mountain, nor in following the outline of the Silver City intrusive to the south. This was considered a possible target area, but apparently the gravel cover is too thick, or other geological complications are present that cloud interpretation of the results.

Information in our files is not clear concerning drilling by Anaconda in the Swisshelm district where favorable limestones probably are present beneath an overthrust, and this zone may not have been fully explored. Certain areas of silicification may warrant some new drilling. The Banner district likely holds a little promise in the deeper Mississippian and Devonian limestones, but here again some drilling was done by Anaconda. The Total Wreck mine in the Empire district has a small replacement body in Permian limestone, but no deeper work is recorded in our files; but the low productivity of the district as a whole suggests that ore bodies may be very small, if present at all.

In view of the report that deeper work at the San Manuel mine has drained the old Mammoth St. Anthony, perhaps the latter may again be of mild interest if some arrangement could be made with San Manuel, the present owner. Asarco's 1952 examination, just before the mine shut down, indicates that 175,000 tons of lead-zinc ore may be found to a depth of 300 feet below the deepest level, the 1125.

On the Ray (Mineral Creek) district replacements in Devonian limestone along faults are known, but the Cambrian beds have not been explored.

The Hansonburg district has some interesting possibilities if the barite and fluospar can be considered credits. Ore occurs in solution cavities in limestone, and the location of these seems to be indicated on the surface by narrow quartz stringers. Some bodies are close enough to the surface for open cut mining.

Only the Mississippian limestone has been explored in the Lake Valley district, yet elsewhere the sensitive horizon for the high silver ores has been in the Silurian. The Silurian dolomite is present and probably only 600-700 feet below the surface. As the ore bodies have been small, a large number of holes would be required to make a test.

Only one limestone bed in the Pennsylvanian has been explored at the Carnahan mine, New Placers district, and deeper, relatively shallow exploration may find similar replacements. The Pennsylvanian lies on the Precambrian so that many of the favorable beds are lacking.

The "Missouri" type lead occurrence at Silver Creek in the Llano-Burnet region, Texas, offers an interesting speculation. Whether or not substantial commercial deposits exist cannot be predicted, but the fact that lead is known and that this type of deposit may be widespread does offer some incentive.

## 3. GEOLOGICAL SETTING OF SOME OF THE LEAD DEPOSITS

The following statements have been prepared in order to attempt to synthesize the various geological settings in which lead deposits of the Southwest occur. They have been divided first into the several ages of mineralization, namely, Precambrian, Paleozoic, Nevadian, and Laramide. The last may include some which are more properly called Tertiary, especially those that are found in some of the younger volcanic rocks. These brief descriptions do show that lead ore bodies may be found in nearly all rock types and under highly variable geological conditions.

### A) DEPOSITS OF PRECAMBRIAN AGE

Two important ore deposits are considered to be Precambrian in age: (1) the Pecos mine in New Mexico, and (2) the Iron King mine in Arizona. At the former a shear zone in Precambrian schist is capped, except for a small window, by Pennsylvanian limestone. Its Precambrian age is suggested because no orogenic activity is known during the Paleozoic in New Mexico. The ore body, now mined out and the property abandoned, produced about 2.2 million tons to a depth of 1250 feet, with an average recovered grade of 0.077 oz. Au, 2.4 oz. Ag, 0.4% Cu, 2.9% Pb, and 9.3% Zn. The mine was first promoted as a copper property and it was not known that lead and zinc were the principal metals until 35 years after its discovery. Apparently the deposit was not thought to be important for many years. Much of the region near the mine is capped by the post-ore sedimentary rocks, and no late re-opening along the known shear zone took place; therefore, this guide is lacking. Thick soil, pine forest, and rugged topography have hindered exploration so that structures, weak at the surface, may yet be found. Search for deposits under the post-ore cover rocks will probably have to wait until geophysical methods are improved.

The Iron King mine has explored through underground workings and diamond drill holes a series of en echelon veins along a strongly altered zone in Precambrian schist to a depth of 3000 feet. Perhaps 5 million tons have been produced to date, and possibly several million more may eventually be extracted, depending on economic conditions. The first million tons averaged 0.13 oz. Au, 4.1 oz. Ag, 2.0% Pb, and 6.2% Zn, but the earliest ore mined contained only gold, silver, and copper. Other prospects may exist in the Iron King area, and these may not be encouraging near the surface.

Many of the other deposits in Precambrian rocks in Arizona are younger in age because Laramide intrusives are present.

### B) DEPOSITS OF PALEOZOIC AGE

In the Llano-Burnet region of Texas disseminated galena occurs in Lower Paleozoic limestones and sandstones, apparently not related to intrusives or to faulting. In most places the galena is found close to exhumed knobs of Precambrian granite and, except for the Silver Creek deposit, all are little more than mineral curiosities. At Silver Creek, however, some lead has been produced from beds that dip radically outward from a small exposure of Precambrian granite.

### C) DEPOSITS OF NEVADIAN AGE

Deposits in the Bisbee and Turquoise districts are thought to be related to Mesozoic intrusives. At both districts mineralization is characterized by silica breccia in limestone that is usually found on the periphery of the lead-zinc bodies.

The limestones are Paleozoic. In the Bisbee district the Mississippian and Devonian limestones contain the largest bodies; the Pennsylvanian and Cambrian are smaller. Mineralization also occurs along structural breaks in the limestones as a jacket around pyrite-copper sulfide bodies, and along dikes and sills. The Tejon mine in the Turquoise district was optioned by Asarco because of similar silica breccia and small amounts of oxidized lead ore that had been mined. The two holes drilled failed to find any ore.

Lead deposits found in other districts in the same general region may also be Nevadian in age; however, complications arise in dating some of the intrusives and in relating mineralization. Deposits in these districts, such as Hartford, Dos Cabezas, and Golden Rule, have been small even though the favorable beds have been tested in many places.

Of all these deposits related questionably to the Nevadian orogeny, only those at Bisbee have been important, and much of the ground is apparently controlled by Phelps Dodge.

In the northwest part of Arizona the quartz veins in Precambrian rocks have been related by some to granitic intrusives and dikes thought to be Jurassic in age. In the Wallapai district about 100 miles of quartz veins are exposed. Ore shoots, usually 3 to 5 feet wide, within the veins have been productive to 1600 feet, but great strike lengths are far below the economic limits.

No ore deposits can be related to the Nevadian orogeny in New Mexico, but it is interesting to note that some of the bonanza silver deposits in Silurian dolomite are also marked by silica breccia.

## D) DEPOSITS OF LARAMIDE AGE

By far the greatest production of lead and zinc ores have come from deposits related to igneous activity that may be dated from Upper Cretaceous to Middle Tertiary in age, a rather broad, ill-defined time interval known as Laramide. In areas where intrusion, faulting, and extensive hydrothermal alteration took place, ore was localized along structural breaks and as replacements in limy sedimentary rocks, some of which in less disturbed areas could be regarded as rather unfavorable horizons. In some districts a broad zonal arrangement of metals is clear where lead (and zinc) bodies lie on the periphery of a porphyry copper. In other districts, however, the intrusive mass may be essentially barren, and alteration within it weak; then the replacements may lie adjacent to the intrusive.

Paleozoic limestones have been the most favorable host rocks in most districts but the particular age varies from region to region. It appears that this is related to (1) the physical and chemical character of the host, (2) the depth at the time of deposition, (3) the lateral distance from the source, (4) the type of underlying rock, (5) the character of the ore-bearing solutions, and (6) the ground preparation.

### 1. Vein Deposits

Vein deposits have been rather well explored as they were easy for the early prospector to find and to work, especially in the oxidized and enriched zones where precious metals were more abundant. Unless it can be shown that more favorable structures, or more favorable wall rocks, exist within reasonable depth, these deposits hold little hope for exploration. In some areas, however, such veins may now be expressed only by barren faults in post-ore rocks because the late re-opening may be a reflection of pre-ore structures in depth.

Lead minerals occur in veins in many ages and types of rocks, except the younger Tertiary and Quaternary. Productive veins occur in many areas, especially in Arizona, in Precambrian schist, granite, and sedimentary formations. A younger age has been ascribed to these because elsewhere in the district ore deposits can be related to Laramide intrusives. Wide veins are known at the Irene mine in the Globe district and at the Reymert mine in the Superior district. The wall rock seems to have little influence on ore deposition, but structural features are important and ore shoots depend more on ground preparation. In the Precambrian rocks of the Bradshaw Mountains (Pine Grove, Tiger, Turkey Creek, and Walker districts) the base metal content is low and the quartz veins have been exploited for gold and silver in the oxidized and enriched zones; in depth values peter out.

Vein deposits in Cretaceous rocks have been more important. The vein in the upper part of the Ground Hog mine, Central district, cuts through Cretaceous shales and sandstones as well as quartz diorite porphyry sills. The Bull Frog vein system is similar. Intense ground preparation, strong hydrothermal wall rock alteration, and pre-ore dikes all are related to ore localization. The Montana mine, Oro Blanco district, explores a wide shear zone at and near a contact between Cretaceous sediments and intrusive diorite porphyry; quartz monzonite was found in drilling at depth.

Veins in limestone are not important. They suggest that ground preparation and mineralization were weak; therefore the original solutions did not have the strength to penetrate and replace the favorable host rock.

Productive veins in Laramide intrusive masses are limited to minor, shallow veins in the Cerrillos district and the Blue Bird mine in the Bunker Hill district, although the latter may be related to breccia pipes. Similar veins do occur in other districts but are unimportant.

Certain of the Tertiary volcanic rocks have been host to modest vein deposits. As the exact age of these rocks is not known, it is questionable whether they are related to the Laramide, or some younger, orogeny. All the mines in the Steeplerock district are in such volcanics. The ore shoots have been relatively small and mineralization dies out at shallow depth. At Tombstone minor ore bodies are known in quartz latite porphyry along shear zones, but the depth to favorable sedimentary rocks may be excessive. In Lordsburg, Red Hill, and Macho districts narrow veins are known in volcanic rocks, but production has been small.

2. Limestone Replacement Deposits

A wide variety of types of ore deposits are included under this heading; their only common feature is that they occur more or less bedded in limestones. Some have a silicate gangue, others simple replacement types, and one related to solution cavities. All are related to faulting and fracturing; many are close to intrusive bodies or dikes. Folding, in general, appears to play a minor part in most deposits.

In one place or another all Paleozoic limestones have been the host and in certain regions one age may be more favorable than another. Cretaceous limestones have been replaced in some areas. Of valuable assistance are paleogeographic maps showing the facies changes as well as widespread knowledge of the probable existence of certain strata.

A large tonnage has been mined in the Central district from the Mississippian limestone and to a lesser extent from the Pennsylvanian. Where remnants of the

Permian are known, the rocks are the clastic Red Bed type and are not a favorable host there. The deeper Lower Paleozoic dolomites have been poorly tested in many places, but where they do crop out or are at shallow depth, exploration has not been successful. All the deposits are related to fracturing, faulting, and intrusion. The ores at the Ground Hog have little or no silicates in the gangue; modest amounts are found at the Combination mine; and the deposits near the Hanover intrusive are high in silicates.

The Magdalena district has had large ore bodies in the Mississippian limestone such as those at the Waldo, Kelly, and Lynchburg mines; but only at the Waldo has moderate production come from the Pennsylvanian strata. The district is bounded on the west by a large fault that drops Tertiary volcanics in contact with Pennsylvanian beds. The vertical displacement may be several thousand feet.

The Pennsylvanian limestone is the host in the Swisshelm and Banner districts. In both districts the deeper limestones (that probably exist) may not be adequately tested, however, some drilling has been done. In many parts of Arizona the Devonian and Cambrian limestones are important, whereas in New Mexico these are unfavorable for replacement as the former is shale and the latter, sandstone.

The Pennsylvanian limestone contains solution cavities in the Hansonburg district where elongated, tubular ore shoots are related to weak fracturing. The ore contains galena, barite, and fluorite.

In the southern part of Arizona the Permian contains limestone beds that contain ore deposits in the Empire and Pima districts. The small ore bodies in the Gallinas Mountains district are also in the Permian.

Peculiar to the southwest part of New Mexico are a number of silver-lead replacements in Silurian dolomite under Devonian shale. Bonanza-type silver deposits were mined, and in most districts only remnants of sulfides remain. The deposits are not adjacent to any important intrusive, although narrow, unmineralized dikes are usually present. The deposits are along small faults and fractures that are not expressed, in many places, through the overlying shale. These districts include Chloride Flat, Georgetown, Lone Mountain, Kingston, Cooks Peak (largely lead), Hermosa, and Victorio. The individual deposits have been small, but the aggregate value is in excess of $20 million. The Lake Valley deposit is similar but in Mississippian limestone; the Silurian has not been explored as far as is known.

Replacement deposits in Cretaceous limestones have been important at Tombstone and Harshaw districts and to a much lesser extent at Hachita, Fremont, and Steins Pass.

3. Other Types

One deposit of the Red Bed type occurs in the Sacramento district at the Warnock mine where Permian sandstone contains galena in a 6 foot bed. As bodies of this type are small, exploration for them is not warranted. A similar deposit, but of silver, was mined some years ago near Van Horn, Texas.

A trace of lead with less than 0.5% zinc is reported in a quartz monzonite intrusive at the Tres Hermanas district, and the mineralization is said to be disseminated. Several holes were drilled a number of years ago by the Eagle

## DONA ANA COUNTY

### Organ District

The district covers a strip 10 miles long following the western slope of the Organ mountains. The core of the range consists of Tertiary quartz monzonite intruding Precambrian granite, Paleozoic limestones, shales, sandstones, and dolomites, and Tertiary flows and pyroclastics. Mineral deposits have been found (1) in veins in the Tertiary quartz monzonite, (2) in veins in Precambrian granite, (3) along a north-trending fault zone that marks the west slope of the range, (4) as replacements in limestones, and (5) as bedded deposits in silicated limestones.

Since 1884 only about 7,400 tons of fine lead have been produced. Silver was an important by-product in many mines; bismuth is widespread in very small quantities. Some ore bodies were largely zinc and others contained only copper.

The Stevenson-Bennet mine, along the north-trending frontal fault of the same name, was operated by Asarco during 1917-18 when we shipped about 5,000 tons of 9 oz. Ag and 20% Pb with some zinc and copper. We also treated at El Paso 1,621 tons of wulfenite ore. In 1948 the Empire Zinc Company drilled the vein below the deepest (450) level, and they estimated about 48,000 tons averaging 2.2 oz. Ag, 5.8% Pb, and 7.0% Zn with an average width of 6.7 feet over a vertical column of 260 feet. The ore occurs in short shoots along faults through Paleozoic limestones.

At the Modoc mine, along the same fault zone, one small lead shoot was found replacing steeply dipping Pennsylvanian limestone.

The Merrimac mine, in the northern part of the district, was bought and operated by Asarco in 1943. The ore occurs in a 2 to 3 foot bed in the Mississippian limestone, converted locally to tactite. The sulfide ore was largely sphalerite with minor galena and chalcopyrite. We put down three diamond drill holes which found nothing of interest. The mine reverted to the State and was also later examined by Empire Zinc Company.

No attractive targets of lead mineralization are present, and in recent years large areas have been withdrawn for the White Sands Proving Grounds.

### San Andres Mountains District

Feeble mineralization with galena, barite and fluorite are known in several places, and many are found at the geologically favorable contact between the Silurian dolomite and the Devonian shale. Nothing in this area warrants study, and much of the area has been taken over by the White Sands Proving Grounds.

## GRANT COUNTY

### Boston Hill District

Close to 2 million tons of manganiferous iron ores have been shipped from open pits in the Lower Paleozoic dolomites. Along the east edge of the district the Mississippian and younger sedimentaries are cut off by the Silver City intrusion. Also near the intrusion weak galena-sphalerite mineralization has been reported in churn drill holes for iron ore. All the country to the south and southeast is covered by Quaternary conglomerate. It had been recommended that geophysical surveys may be able to locate the Carboniferous limestones beneath the conglomerate near the intrusive, and this situation may be favorable to lead-zinc replacement bodies. The geophysical surveys have been completed and have not been able to locate the limestones.

## GRANT COUNTY (Con't)

### Central District

The Central Mining District includes the most highly mineralized area in New Mexico and for many years has produced the greater share of non-ferrous mineral wealth of the State. Except for the porphyry copper deposit of Kennecott at Santa Rita, the lead and zinc mines are now limited to operation during favorable metal market conditions. The extensive hydrothermal alteration and generally favorable geological conditions have also lead to active exploration by a number of important mining companies.

The lead and zinc deposits include the following types:

(1) Veins in Cretaceous shales and sandstones and later quartz diorite porphyry sills. Under this type are the Ground Hog vein, the Bull Frog vein system, the Peerless vein. The Ground Hog has probably produced more lead than any other mine.

(2) Replacement deposits in limestone. The favorable limestone has been either Pennsylvanian or Mississippian in age and the latter is the host for the larger bodies. These replacement deposits, as exemplified by the deeper Ground Hog mine and the Maggie mine, are less leady.

(3) Pyrometasomatic deposits in limestone. Here again the Carboniferous limestones form the original host, now completely metamorphosed to garnet and other silicates. The ores, such as those at the Pewabic mine, Copper Flat mine, the Empire Zinc properties, and the Combination mine, are largely zinc, in some places lead-free.

The district geology is complex in detail. Following the long period of Paleozoic deposition of sediments the region was uplifted and slightly tilted as the basal Cretaceous quartzite overlaps the earlier sequence. Several thousand feet of later Cretaceous shales and sandstones were then laid down. The end of the Cretaceous is marked by extensive intrusion and faulting. The intrusives include sheets and sills of quartz diorite porphyry, granodiorite stocks, quartz monzonite porphyry stocks and innumerable dikes. Strong northeasterly faulting took place during and after intrusion. Ore deposits were formed in structural favorable locations along the faults and around the intrusives. Post-mineral Tertiary volcanics and pyroclastics covered much of the area and these were also faulted; some faults are re-openings on pre-mineral structures.

Large areas in the southeast parts of the district, especially in the hanging wall of the Ground Hog fault system, are capped by the late Tertiary volcanics. Some exploration has been carried on by Asarco to test the post-ore faults in depth. Some mineralization, but no ore, has been found to date. Certain structures in the footwall of the Ground Hog also show some promise but have not been fully explored. The Ground Hog and probably other structures continue towards Lone Mountain district, but all the surface is covered by post-ore rocks. Until geophysical methods are improved, exploration will be hard to justify because (1) the limestones are at great depth because the trough of the Fort Bayard synclinorium passes through the area, (2) the mineralization along the Ground Hog structure weaks to the southwest, and (3) where the limestones again rise to the surface at Long Mountain, ore bodies of consequence are lacking.

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Within the highly mineralized part of the district exploration has generally stopped at the base of the Carboniferous limestones. They are underlain by several hundred feet of Devonian shale below which perhaps 700 feet of Lower Paleozoic dolomites are present in the normal stratigraphic section. The contact between the Devonian shale and the dolomite elsewhere has been a sensitive spot for silver-lead ores, but in the Central district these rocks could be at too great a depth or too close to the intrusions for the formation of the low temperature deposits.

No completely new targets seem to present themselves, but several incompletely explored ones do exist. The mines have been plagued by high costs and at present the production of lead-zinc ores is nearly at a standstill, although reserves do exist. The trend in depth has been towards high zinc and low lead-silver content.

Chloride Flat District

All the known ore deposits and mineralization occur in Lower Paleozoic dolomites and especially immediately below the Devonian shale. Although most of the value of production has been from silver haloids and other oxidized minerals, some galena is found. Base metal metallization nevertheless is feeble, and no exploration targets exist.

Georgetown District

Ore occurrence is like that at Chloride Flat. The district has been more or less dormant since the 1890's.

Gold Hill District

In Precambrian rocks narrow veins with quartz and minor argentiferous galena have been explored, but the yield has been very small. No hope can be held for the development of even a relatively small mining venture.

Hachita District

Small ore bodies in veins and as replacements in a thick series of Cretaceous sedimentary rocks have been mined; some ore is found in Lower Tertiary volcanics. All are close to a small monzonite stock. All the ore bodies have been small and none have yielded more than about 25,000 tons. The more important mines have been examined in the past, and no exploration targets seem to be present.

Lone Mountain District

Rich silver ores have been mined largely from Lower Paleozoic dolomites; some deposits contained argentiferous galena. As these hills are surrounded by alluvium, a speculative chance does exist that additional ore bodies, presumably of the lead-zinc type, could exist along the projection of known structures in the Central district in the favorable Mississippian limestone. Mapping in the northwestern part of the district suggested that concealed faults may also be present. Geophysical surveys were not able to solve these problems.

Pinos Altos District

The geologic history is complex. Involved are intrusion, faulting and folding, and thrusting. Except for a relatively small area, the favorable Paleozoic limestones are buried or stoped out by intrusion.

Gold veins were mined within the Pinos Altos granodiorite stock during the last century. The Empire Zinc Company mined 125,000 tons of zinc-lead sulfide ore from replacement bodies in limestone at the Cleveland mine between 1915 and 1919, and in more recent years the Houston-Thomas mine has yielded similar ores. The

## GRANT COUNTY (Con't)

district was rather throughly explored some 15-20 years ago by the U. S. Smelting Company and others; and about in 1948 we drilled several holes around the nearby Gomez Peak intrusive without successful results.

The only long-range exploration target that may exist lies to the east of the Pinos Altos granodiorite where the outcropping rocks have been mapped as late Cretaceous volcanics (post-Colorado), but one would probably be confronted with a great thickness of Colorado shale and sandstone before the Paleozoic limestones would be reached.

### Steeple Rock District

Tertiary volcanics crop out throughout the district, and may be intruded by a diorite porphyry. A complex vein system, clearly marked by prominent quartz-calcite outcrops, cuts the volcanics. Within these veins complex sulfide ores containing lead-zinc-copper-silver-gold minerals have been mined on a large enough scale to allow the operation of several small mills. Metallization died out in depth. No better host rocks can be projected into the vein system within reasonable depths. Practically all the mines and prospects have been examined and considered by Asarco in past years.

### Swartz District

Lead-zinc sulfide replacement bodies have been found in Paleozoic limestones along faults, but only two small productive mines have even been developed-- the Royal John and the Grandview. The combined production has been less than 60,000 tons of about 1 oz. Ag, 1% Cu, 3.5% Pb, and 6% Zn. Asarco operated the Royal John mine in 1928.

Although good conditions are present for replacement bodies, only small ones have been found to date, and no reason can be given to justify additional exploration. Sources of lead will depend on small operations.

## HIDALGO COUNTY

### Apache No. 2 District

Minor showings of galena are found in stringers in volcanic rocks, and small bodies of argentiferous galena have been extracted from the Apache mine. Essentially the future of the district lies with the speculative possibility of copper ore in tactite zones.

### Fremont District

Pennsylvanian and Cretaceous limestones are cut by granite porphyry dikes. Mineralization is found as small replacement bodies of galena with minor sphalerite in some of the limestones and in small shoots in quartz veins cutting the limestones. Some years ago at least five diamond drill holes were put down by some company, one to about 1000 feet. Apparently the results were discouraging.

### Lordsburg District

All the rocks in the district are igneous and consist of andesitic volcanics intruded by an irregular stock of granodiorite, probably of Laramide age. Locally the rocks are brecciated. The district is noted for the long, deep continuous ore shoots containing copper minerals in a quartz-tourmaline gangue. These veins are well-exposed. Lead-bearing veins are found in the northeast and east parts of the district where young gravels overlap the mountains.

## HIDALGO COUNTY (Con't)

The possibility exists that other veins may be found under the gravel cover, but the production from the known ones has been so small that much of the incentive for blind prospecting is lost. No valid reason can be found to expect better or larger ore bodies beneath the gravels.

### Red Hill District

Beneath a single outcrop two diverging veins are found in depth. These occur in Tertiary volcanic rocks which overlie Cretaceous sandstone and shale, the upper part of which has a few thin beds of marine limestone. Exploration has been to 476 feet, all in the oxidized zone. The depth to the thin limestones is not known but probably within 1000 feet of the surface. The formations in depth do not present an attractive target.

### Steins Pass-San Simon District

Cretaceous and Paleozoic sedimentary rocks lie on Precambrian granite, but a large part of the area is covered by late Cretaceous and Tertiary volcanic and pyroclastic rocks. Quartz monzonite porphyry occurs as sills, dikes, and irregular intrusive masses; it is related to the ore deposits. The more important deposits are found in limy rocks and associated with tactite areas where small ore bodies containing base metals have been mined. Some ore has also been mined from veins in limestone.

At the Carbonate Hill mine ore is found in the Creatceous formations, and the deeper Pennsylvanian and Mississippian limestones have never been tested; however, these may be 2000 feet below the present workings which are 500 feet. The Silver Hill mine, which has been operated in the past by Phelps Dodge and Peru Mining Company, explores beds in the Pennsylvanian limestone adjacent to a quartz monzonite porphyry sill. Replacement ores also occur at the Granite Gap mines where Carboniferous limestones have been strongly broken and fractured. Dikes are present, but garnet and other silicates are lacking.

All the elements for substantial lead-zinc deposits appear to be present in the district, but the amount of metal introduced was small. All the mines have received cursory examinations from time to time.

## LINCOLN COUNTY

### Gallinas Mountains District

Sedimentary rocks of Permian age lie directly on Precambrian granite and gneiss. These have been intruded by syenite porphyry laccoliths and monzonite porphyry sills and dikes; several monzonite breccia pipes are reported in the northwestern part of the district. Base metal mineral deposits are related to fracture zones within Permian limestone. Probably the most important lead mine has been the Red Cloud where the lead (with copper) ore was found in fault and breccia zones in limestone. The property was carefully examined many years ago and an attempt was made to option it; however, satisfactory terms could not be negotiated. Later exploration by others found that the mineral terminated at shallow depth.

The fact that the favorable Pennsylvanian and Mississippian limestones are missing is a strong deterrent for exploration.

## LUNA COUNTY

### Cooks Peak District

In the 19th century the district was an important producer of high-grade oxidized lead ores, and the district was studied several years ago. The core of the range is formed by a granodiorite intrusion of Tertiary age and cuts through Paleozoic and Mesozoic sedimentary rocks; in general, the typical sedimentary section of the Central district is present. A major northwest-trending fault limits mineralization along the northeast side of the range, and smaller northeast-trending faults lie to the southwest. Practically all the ore has been found in the Silurian dolomite beneath the Devonian shale; the Mississippian here is shaly and where known in structurally favorable areas, it has not been ore-bearing. To explore to the northeast of the major fault would be futile as the uppermost Pennsylvanian beds are probably well over 1000 feet below the surface. The old mines are practically worked out, and no exploration targets are known in them.

### Florida Mountain District

The mountains consist of a complexly faulted stock of Lower Paleozoic, Mississippian, and Permian (note the absence of Pennsylvanian) sedimentary rocks lying on Precambrian granite. The north part of the range is underlain by Tertiary volcanics and pyroclastics. Minor occurrences of lead have been found in Orodovician and Silurian dolomite in veins and along narrow dikes. One narrow lead vein has been explored in Tertiary agglomerate. The district offers no hope for other than local pods from which a few tons of lead ore may be found.

### Tres Hermanas District

The high peaks and rugged center part of the Tres Hermanas mountains are formed by a circular stock, covering more than 10 square miles, of quartz monzonite. It intrudes Paleozoic sedimentary rocks and Tertiary volcanics. In the northwest corner of the district small replacement deposits of lead and zinc, now all oxidized, have been exploited. In the west part of the district are several narrow but persistent veins that cut through Lower Cretaceous sedimentary rocks, early Tertiary volcanics and pyroclastics, and altered Paleozoic limestones. Of additional interest is exploration done by Eagle Pitcher in 1937 when they drilled several holes into altered quartz monzonite in an attempt to find a disseminated lead-zinc sulfide deposit. The combined lead and zinc assays were about 0.5%.

An altered zone in the quartz monzonite trends northeastwards and dives under alluvium that forms a re-entry in the northern part of the mountains. Geophysical surveys have been recommended to (1) attempt to delineate the contact between the quartz monzonite and the Paleozoic sediments under this cover, and (2) attempt to determine if sulfides may be present in the sediments. These surveys have not found any target.

### Victorio District

Only Lower Paleozoic dolomite are exposed at Mine Hill, except for one small dike and a few outcrops of Lower Cretaceous sandstone and conglomerate that lie to the northwest of a major northeast-trending fault that de-limits the hill. Mineralization, largely lead with good values in gold and silver, is localized along faults and moderate replacement of the dolomite wallrock. All the ore mined has been oxidized and for the 30,000 tons mined this century, the average grade has been 0.12 oz. Au, 6.1 oz. Ag, and 9.2% Pb. The most productive part of the district lies along the west edge of the hill where Quaternary alluvium overlaps the outcropping Silurian dolomite. Possibly other small ore bodies are present under the alluvium,

## LUNA COUNTY (Con't)

but prospecting for such bodies would be extremely hazardous unless some geophysical method would assist to confine the target.

## OTERO COUNTY

### Sacramento District

Sedimentary rocks from Orodovidian to Permian are exposed, and of principal interest in this district is the Permian (Abo) formation. Overlying a conglomerate of chert and limestone pebbles are arkosic sandstones that grade upward into silty sandstones. The sandy members are lenticular and are enclosed in red mudstones. Its thickness is about 250 feet. The only igneous rock is a syenite porphyry that intrudes the Pennsylvanian limestone as sills. Faults have offset beds. Moderate folding of the Permian has been noted throughout the area.

Lead ores have been shipped from the Warnock mine. These are considered to have been deposited by circulating meteoric waters, and thus are similar to the Red Bed copper deposits. The known ore bodies, now mined out, have produced about 1000 tons of fine lead from a bed about 6 feet thick. This district was examined by Asarco in 1948 with the hope that reason could be found to indicate that the underlying Pennsylvanian and Mississippian limestone could be ore hosts. The Empire Zinc Company also did exploration in the district. Whether or not other lead deposits lie buried may only be answered by geophysical work.

## SAN MIGUEL COUNTY

### Willow Creek District

Windows of Precambrian granite, schist, and diabase crop out in certain of the canyons throughout the area. The Precambrian is capped by Pennsylvanian and younger sedimentary rocks all of which are post-ore. The only mine is the Pecos, owned and operated by American Metals between 1926 and 1939 when about 2.2 million tons with an average recovered grade of 0.077 oz. Au, 2.4 oz. Ag, 0.4% Cu, 2.9% Pb, and 9.3% Zn. Ore occurred in a saucer-shaped shear zone in the Precambrian rocks. Two principal ore bodies were mined, but these were lenticular in detail. Post-mineral movement was wide-spread, and a large fault has been reported at the north end of the zone. Mining went down to 1200 feet and exploration to 1750 feet. Over 20,000 feet of surface drilling was done in a search for the extension of the shear zone and for parallel shear zones without success.

The presence of a substantial Precambrian lead-zinc deposit in an area where much of the country is covered by younger rocks, and where soil covers much of the mountains has naturally led to much speculation. We have done some reconnaissance soil sampling and have found one anomalous area that will require some future work.

## SANTA FE COUNTY

### Cerrillos District

Many mines in the Cerrillos district have been examined by Company engineers, but all reports indicate small, narrow vein deposits of no interest to Asarco for an operation. Mesozoic sandstones and shales have been intruded by several phases of monzonite porphyry. Fracture systems were developed in the intrusive and localize short ore shoots with galena, sphalerite, and chalcopyrite with minor silver

## SANTA FE COUNTY (Con't)

and gold. The near-mile thickness of the Mesozoic rocks precludes any reasonable justification for exploration of the Pennsylvanian limestone for replacement bodies.

The total production between 1909 and 1952 was less than 26,000 tons of ore. The district has a cloudy future.

### New Placers District

Nearly all the mining has been from the San Pedro copper mine that was carefully examined by us in 1946 and several drill holes put down. Just south of the San Pedro is the Carnahan mine where a pipe-like flat-dipping replacement in Pennsylvanian limestone has been explored for about 3000 feet. Galena, sphalerite, pyrite, and alabanite replace the limestone for horizontal widths of 5 to 40 feet and vertically for 5 to 10 feet. It appears that only one bed in the series has been tested. The mineralization is weak. Between 1925 and 1928 about 27,000 tons of sulfide ore were mined; in earlier years possibly as much as 50,000 tons of oxidized manganiferous lead-silver ore were shipped. Additional exploration may find similar bodies in depth.

## SIERRA COUNTY

### Hermosa District

A window of Lower Paleozoic dolomite is exposed in Palomas Creek. Small pockets and lenses of argentiferous galena have been mined from minor fractures and faults. Some zones have not been fully explored; nevertheless the nature of known shoots with their small scattered amounts of high-grade ore discourages future prospecting.

### Kingston District

Kingston was another of the early, high-grade silver camps and before 1904 was one of the largest in the State. The ore, largely enriched and oxidized, is found in the Lower Paleozoic dolomite along fractures and at the crest of minor anticlinal folds immediately below Devonian shale. The sulfide ore contains argentiferous galena and sphalerite in a manganiferous gangue (including alabanite). An occasional small shipment may be made by leasing operations.

### Lake Valley District

The Lake Valley district was also noted for rich, oxidized silver ores in the last century. Very little sulfide ore has ever been found, and it consists primarily of galena with 4 to 8 oz. Ag per 1% Pb. The gangue is iron and manganese oxides, and during times of emergency the latter has been mined.

The ore bodies occur in certain horizons in the Mississippian (Lake Valley) limestone and conform to the gentle dip of the bedding and, in a general way, are associated with east-trending faults and fracture zones. No intrusive rocks crop out nearby, but Tertiary volcanic rocks cap the country to the south.

The Devonian shale and Lower Paleozoic dolomites crop out west of the mining area, but they have not been prospected by underground workings any place. Our files show that between 1885 and 1886 at least four diamond drill holes put down; these are said to range from several hundred to 1000 feet each. Unfortunately,

## SIERRA COUNTY (Con't)

no logs were ever found, but they must have penetrated with lower dolomites. They were drilled, however, 200 to 600 feet southeast of known ore bodies, and therefore, may not have tested the best areas. In most places, surface holes 600-700 feet would reach the first dolomite. A speculative target is therefore offered in this district. The last information shows that the claims are owned by Haile Mines.

### Macho District

A narrow lead-silver vein crops out in Tertiary volcanic rocks, and it has been explored through a vertical shaft (now caved) to a depth of 500 feet, and a drill hole cut Silurian dolomite at 800 feet below the surface. Old sampling on the 100-level shows a vein about 3 feet wide with about 6 oz. Ag per ton, 8.5% Pb, and 2% Zn; some bismuth occurs with the galena. A small tonnage of jig tailings that may assay 3 oz. Ag per ton and 3% Pb remain at the surface.

Wild-cat drilling to intersect the projection of the vein with the reported dolomite may find new ore shoots.

## SOCORRO COUNTY

### Hansonburg District

Lead-barite-fluorspar ore is found in solution cavities in Pennsylvanian limestone. The possibility exists that as much as one million tons of this mixed type of mineral could be found in bodies scattered along a strike length of about two miles. The mineralization only partly fills the cavities with large crystals of galena, barite, and fluorite. All known bodies are related to faults. Unconfirmed data suggests that a grade of 3 to 4% Pb, 20 to 25% barite, and 6 to 15% fluorspar may be possible. The district is under three ownerships, including the Sunshine Mining Company, who did considerable underground exploration and drilling.

If satisfactory concentrates and recoveries can be made on the three principal minerals, these deposits may be valuable sometime in the future.

### Magdalena District

Important limestone replacement bodies of lead and zinc are found in the Mississippian limestone and to a much lesser extent in the Pennsylvanian. We operated the Waldo mine from April, 1943, to June, 1949. The Kelly and the Lynchburg mines are owned and have been operated by the Empire Zinc Company. Many other smaller properties have contributed towards the total $45 million production.

During the period we operated, a number of other groups were optioned and drilled without finding any commercial deposits. The district is now largely mined out, except for possibly the Lynchburg.

### Water Canyon District

This small district adjoins the Magdalena district on the southeast, and small, unimportant bodies of lead-zinc ore have been found in the Mississippian limestone at its intersection with fissures. Mineralization is very weak.

## COCONINO COUNTY

### Havasu Canyon District

A lead property owned by Havasu Lead and Zinc Mining Company and located at the bottom of the Grand Canyon has been brought to our attention many times since 1915. The deposit is a small replacement in Mississippian (Redwall) limestone where galena and cerrusite with smithsonite and vanadinite have been mined. Another mine, called the Grand Reef near Fairview, shipped a few cars of lead-silver-copper ore many years ago, but no data is available on the deposit.

## COCHISE COUNTY

### Bisbee District

Replacement bodies of first-order importance have been mined from the Mississippian and Devonian limestones, and to a lesser extent from Pennsylvanian and Cambrian beds. One body is described as over 200 feet high, 500 feet long, and 50-250 feet wide.

The replacements occur (1) along structural breaks which may be one or a set of fissures with the ore minerals replacing the adjacent limestone; (2) associated with great masses of silica breccia with the sulfide mineralization on the periphery and occasionally within the mass; (3) jacketing the massive pyrite-copper sulfide bodies; and (4) along dikes and sills. Of interest is the relation between the silica and sulfides. The age of intrusion and mineralization has been under discussion for many years, but some believe it is Nevadian.

Apparently most of the district is controlled by Phelps Dodge. Exploration targets may exist, but no original work has ever been done by Asarco.

### California District

A number of mines have been examined by Asarco engineers and probably the best known is the Hilltop which was explored by American Zinc Lead in the 1950's. They are reported to have found 50,000 tons of sulfide ore and concluded that it was too small for their company to operate. Our reports state that the main ore showings are replacements in limestone associated with silicification (but called quartzite by another engineer). The limestone is traversed by fractures and faults and cut by porphyry dikes. Ore bodies occur along a strike length of 4700 feet as detached pods localized by fissures.

Other mines in the district, such as the Black Queen, Oxbow, and Devonian, test narrow veins in limestone and porphyry and along the contact between the two rocks. Mineralization is always low grade.

Important exploration targets are lacking at the Hilltop because the known replacements in more favorable, deeper limestones may not be within any reasonable depth on account of the steep dip of the beds. Elsewhere all reports point to sporatic, weak mineralization under more or less favorable geological conditions.

## COCHISE COUNTY (Con't)

### Dos Cabezas District

Precambrian schist and granite are overlain by the standard Paleozoic sedimentary section in southeast Arizona. These rocks are in turn overlain by Cretaceous sediments and Cretaceous(?) and Tertiary volcanics. Various intrusive masses and dikes, some pre-Cretaceous in age, cut the older rocks. The entire mountain range is complexly folded and faulted.

Between October, 1915 and April 1918 Asarco leased and operated the Mascot copper mine where ore occurs in small lenticular bodies in volcanic rocks. Narrow veins in Precambrian and Paleozoic rocks have produced small amounts of lead-gold ore. Descriptions indicate that favorable geological factors are present at the surface, but only minor, weak mineralization has been found.

### Golden Rule District

This district has only one mine of any importance, the Golden Rule, and our examination shows it to be $1\frac{1}{2}$ - 2 feet of quartz with oxidized lead minerals that replaces a limestone horizon near a granitic intrusion. Newmont may have conducted geophysical surveys in 1952.

### Hartford District

The Hartford district includes the Huachuca Mountains which are made up of Precambrian granite overlain by Paleozoic limestones and shales and Lower Cretaceous clastic sediments capped in the northwest part of the range by Tertiary(?) volcanics. The Cretaceous and older rocks are invaded by a quartz monzonite stock measuring $2\frac{1}{2}$ by 7 miles. The rocks have been deformed by folding and displaced by thrust, reverse, and normal faults.

The State of Texas mine has yielded less than 2000 tons of complex lead-copper-zinc-silver ore in a silicate-calcite-quartz gangue. A metamorphosed contact zone 100-150 feet wide of limestone, shale and conglomerate against granite contains a few scattered bunches of lead and zinc, which seems to be related to fissures and folding. A few tons have been shipped from other properties, but none warranted investigation.

### Johnson District

The main production has been copper-zinc ores from the Republic and other mines owned by the Mudd interests. The ore occurs as replacements largely in the Cambrian (Abrigo) formation; the largest individual body measures 1500 feet long, 30-100 feet wide, and 15-40 feet thick. Alteration to silicates is widespread. The rocks are cut by many east- and northeast-trending faults of small displacement. South of the ore zone, 2000-4000 feet, is a large quartz monzonite intrusion of post-Cretaceous age. The Peabody mine has more lead, and the Texas-Arizona mine is said to have lenses of silver-lead with some zinc. No deeper limestones than the Abrigo exist; therefore, exploration possibilities seem to lie largely in the alluvial-filled valleys to the east and west. To the southwest the intrusive goes under alluvial material so that nothing is known of a possible repetition of a similar fault and fracture pattern near its southwest boundary. Possibly geophysics could help if the alluvium is not too thick, or strongly cemented.

## COCHISE COUNTY (Con't)

### Swisshelm District

The typical Paleozoic sedimentary section is present in the Swisshelm Mountains as well as Cretaceous clastics and Tertiary rhyolite flows. The Cretaceous and older rocks are intruded by granite that lies several miles to the southwest of the mining area. Thrust faulting has moved Upper Paleozoic rocks over Lower Paleozoic and crumpled the strata in the overthrust plate. Normal faulting adds more complications. In places along the thrust in the mining area diorite porphyry has been injected as a sill (but the Company report calls this formation pre-Cretaceous volcanics). Extensive areas of silicification have never been explored carefully.

Small replacement bodies of lead ore occur along fractures and under thin sills in Pennsylvanian limestone in the upper plate.

The exploration target considered apparently before Asarco entered the district by Anaconda was bodies in the lower plate in the Mississippian and Devonian limestones. Several holes were drilled by Anaconda, and although we never could obtain logs, presumably results were discouraging as Anaconda dropped their option.

We had an option in 1950 on 15 claims in three separate groups held by three different owners. The options were dropped because after examination the exploration targets appeared to be unattractive. It was recognized that some work may be warranted in the silicified zones.

### Tombstone District

About 95% of the value of the production has been from precious metals, but most of the small remainder was from lead. In 1933-34 Asarco operated the Tombstone Extension mine under lease and produced about 24,000 tons of 0.055 Au per ton, 9.5 oz. Ag per ton, and 18.4% Pb. The Charleston mine explores a shear zone in Tertiary flows and quartz latite porphyry with about 10% combined Pb-Zn. The ore width is about 5 feet, but the alteration halo measures 1200 feet by 80 feet. The property was rejected after careful examination. The Vogel mine, also examined, covers narrow veins in volcanics that could overlie the more productive sedimentary rocks; however, the volcanics may be 600-1000 feet thick.

Thought has already been given to geophysical work to hunt for targets under the alluvial cover to the northeast. In 1949 we had options on several parcels and located a few additional claims. In this area the lead content is much higher than in the main part of the district to the west, held in 1950 by Anaconda.

Because of the complex geology and the thickness of the gravels, it was concluded that geophysical methods could not be of material assistance in delineating targets for drilling. Options and claims were dropped.

### Turquoise District

Thrust faulting followed by steep normal faulting has complicated the geology. All of the standard Paleozoic strata, except the Devonian, crops out. Quartz monzonite porphyry intrudes Paleozoic and earlier rocks but not Cretaceous; and granite cuts Cretaceous strata. The quartz monzonite type has offshoots in the form of sills and dikes and seems to be more closely related to mineralization.

## COCHISE COUNTY (Con't)

Northeast fractures with little or no displacement are also associated with mineralization.

In 1947-48 Asarco obtained options on certain ground known as the Tejon, or Tom Scott, mine. A large mass of silica breccia was considered an attractive feature as it was similar to the silica breccia at Bisbee where it is a guide to lead-zinc ores in the limestones. Some oxidized lead carbonate ore was mined in and around the silica breccia at Tejon. Two drill holes were put down at a favorable location, but no mineralization or encouragement for further drilling was found.

## GILA COUNTY

### Banner District

Lead-zinc ores, some with copper, have been produced from replacement bodies at the "79" mine (last operated by Shattuck-Denn in 1948), and small amounts from the London-Arizona and Curtin mines. Our examination shows that the replacement bodies occur in Pennsylvanian and Mississippian limestones around a quartz-diorite intrusion.

At the London-Arizona Asarco put down 2 drill holes in 1915 searching for a favorable bed in the Devonian limestone but failed to find it. Many holes were drilled by Shattuck-Denn at the "79" mine without finding new ore bodies, but there seems to be some question whether or not the favorable Devonian horizon, presumed to be 500-900 feet below the deepest mine working, was ever cut. Anaconda may have done some drilling at a later date, otherwise there still may be a highly speculative chance for new ore. The total production for the upper beds is less than 100,000 tons.

Elsewhere in the district the Pennsylvanian limestone has produced small amounts of ore from the Pennsylvanian and probably the deeper Mississippian and Devonian have not been explored. In the Dripping Springs area ore has been mined from fault zones in Precambrian quartzite, but these are not important and no other exploration targets seem to be present.

### Globe District

The Irene mine, 3 miles north of Globe, covers several veins, one up to 25 feet wide, in diabase, Cambrian and younger sedimentary rocks. In 1944 Asarco drilled the property, but results were disappointing. The RFC also drilled and found some sphalerite and silver-lead-zinc manganese oxide ore in the Devonian limestone. We also examined the Money Metals Mining Company property $7\frac{1}{2}$ miles northwest of Globe but found only low grade lead-zinc-silver-gold mineralization in quartz lenses in Precambrian diabase.

The Defiance mine, north of the Irene about 2 miles, explores a steep-dipping vein in Precambrian quartzite and diabase. Lead occurs as the carbonate, with remnants of galena; oxidized vanadium minerals are also present. A small tonnage of carefully sorted ore has been shipped from stopes that average about 5 feet wide.

## GILA COUNTY (Con't)

### Pioneer District

At the Pioneer mine two northeast fault zones 600 feet apart and 800 feet long traverse quartzite and conglomerate. Some high-grade silver ores were shipped, but in depth the values dropped and the lead-zinc increased. The ore is 4 to 10 feet wide.

## GREENLEE COUNTY

### Metcalfe District

The Lime Cap mine located in Chase Creek one mile off Highway 666 was examined and reported to have oxidized lead-zinc with some vanadium in a limestone bed 2 to 5 feet thick with a known length of 375 feet. The mineralization is confined to fracture zone. The report does not state what beds probably exist in depth or other geological features.

## GRAHAM COUNTY

### Aravaipa District

The district has been examined several times by Asarco, the most recent being a comprehensive study in 1952. The district has produced about 220,000 tons with 1.4 oz. Ag per ton, 6% Pb, and 3% Zn.

The sedimentary section is somewhat thinner and more shaly than elsewhere in southeastern Arizona. Cambrian limestones are missing and the Devonian is more shaly and thin. The combined thickness of the Pennsylvanian and Mississippian is about 1000 feet. The Cretaceous beds are largely shale and sandstone with interbedded volcanics. A large mass of granite intrudes all the above rocks; large areas of rhyolite porphyry crop out in the mineralized area. Tertiary flows and pyroclastics overlap the sedimentary rocks.

The ore deposits occur as veins and replacements. The veins are found along low-angle faults near the rhyolite porphyry intrusives. The replacement deposits are in the Pennsylvanian limestone and are associated with silicate minerals.

The examination showed that exploration targets were probably small. At the same time the adjoining Stanley district was rejected where minor showings of lead are found in veins in flows.

## MARICOPA COUNTY

### Big Horn District

The report on the Atkins property states that a quartz-calcite vein 10 feet wide and 1400 feet long crops out in granite. Values are low and spotty.

### Sunflower District

The Tri-Metal mine covers shear zones that follow the schistosity in Precambrian schist. The zones, however, average 2 feet or less in width and can be traced by about 600 feet. Some oxidized lead-silver ore may exist.

## MARICOPA COUNTY (Con't)

### Vulture District

Small showings of lead carbonate are found at the Moon Anchor mine in a vein $1\frac{1}{2}$ to 5 feet wide and 500 feet long in volcanic rocks, but mineralization is spotty and scattered.

## MOJAVE COUNTY

### Owens District

Showings of lead are found in narrow veins in volcanic and intrusive rocks, such as the Lead Pill where a 1 to 4 foot vein with galena in a calcite-fluorite gangue crops out in monzonite porphyry.

The McCracken mine has a vein zone, up to 30 feet wide and 5000 feet long, in granite gneiss. Rich silver-lead ore was mined near the outcrop, but at 400 feet only traces of metal were found. One report states that 700,000 tons of 8 oz. silver and 1.6% Pb remain, but the ore is mixed oxide and sulfide. Only low recoveries can be made.

### Wallapai District

Rocks of the Precambrian complex are cut by Jurassic(?) granite and by dikes. The ore deposits occur as fissure-filled quartz veins that form long conspicuous outcrops, that produced bonanza-type silver ore. The veins are numerous; one report estimates a total length of 100 miles of mappable veins.

A detailed study of the district made in 1949 indicates that great strike lengths of vein material is far below the economic limit. The widths usually range from 3 to 5 feet, and in recent years the sulfide ore averaged 0.09 oz. Au, 3.6 oz. Ag, 2.4% Pb, and 3.7% Zn. At the Tennessee mine workings go down to 1600 feet.

The district study and the examination of many individual mines strongly suggest that no important exploration targets can be pointed out. Undoubtedly, small new ore shoots may be discovered from time to time.

## PIMA COUNTY

### Arivaca District

The geologic map of Arizona shows that Cretaceous sedimentary and volcanic rocks are cut be a Laramide batholith. At the Black Hawk mine rhyolite and andesite flows are intruded by quartz porphyry masses. Stringers and veins up to one foot wide have local pods of good silver-lead-copper-zinc ore. The Bent, Oreona, and Amado mines have short narrow quartz lenses with gold-silver-lead values on or near the contact between the intrusion and Cretaceous sediments and volcanic rocks. No chances for replacement deposits seems likely.

### Cerro Colorado District

The geologic conditions appear to be similar to the Arivaca district that is located about 6 miles to the southwest. The Princess group and the Mary G mine both explore narrow veins, up to 2 feet wide, in volcanic rock. Copper occurs with the lead and silver.

PIMA COUNTY (Con't)

Comobabi District

Cretaceous andesite is intruded by Laramide granite according to the geologic map of the State. A one to two foot vein with galena, sphalerite, and chalcopyrite in a quartz and pyrite gangue in andesite has been explored at the Wayne mine. The Little Mary group covers two parallel quartz veins 800 to 1000 feet apart; one vein is 2 to 4 feet wide and the other 4 to 6 feet. The ore minerals are galena and chalcopyrite. The general belt in andesite with rhyolite dikes extends for about 3 miles where at the Picacho mine exploration went to 300 feet. Sampling in 1922 showed the values to be too low.

Empire District

Pennsylvanian and older limy rocks have a thickness of over 2250 feet and are overlain by Permian and Upper Cretaceous strata that range from 6500 to 10,000 feet. These are intruded by a stock of quartz monzonite considered to be Laramide. Thrust faulting has moved the Paleozoic over the Cretaceous. Large tear faults and smaller normal faults are common.

Ore occurs in the limestones as replacements in Permian limestone. The Total Wreck has produced the larger share of the district output, and all the ore was essentially oxidized. The limestones that dip moderately to the southeast have been affected by east-west fissures and northeast faults, but these structures disappear under a form and extend outward into the limestones as replacements to as much as 100 feet. Although commercial ore was found only above the 350 level, the mine has been explored to the 500. On the 450 level is a breccia zone 40-50 feet wide. Possibly this requires some study.

At the Chief and Gopher mines ore is limited to pipes formed by the intersection of crossing fracture zones. At the "49" mine an elongated body was formed at the intersection of a lime bed and a rhyolite porphyry dike.

Since all the ore found to date is in the Permian beds, the deeper limestones should also be favorable hosts. Highly complex structure involving thrusting and folding may prevent solution of the problem.

Meyer District

At the Gunsight mine two sets of crossing vein systems cut Laramide granite. The veins range from 4 to 12 feet wide and are marked by 1 to 2 feet of quartz on both walls with the center composed of wall rock fragments, calcite and barite. Samples show values nearly all in silver, but values die out at 200 feet.

Papago District

Andesite is intruded by several quartz porphyry dikes at the Champarado mine. The outcrop of the mineralized area is marked by a heavy gossan up to 20 feet wide and 150 feet long. Only weak copper-lead mineralization was found in depth. At the Sunshine-Sunrise mine thin fractures in limestone are filled with argentiferous galena; however, a deeper adit failed to find any mineralization.

## PIMA COUNTY (Con't)

### Pima District

In the 1940's the San Xavier mine, operated by Eagle Picher, was one of the important lead-silver operations in the State. In this district replacement bodies seem to favor the less pure limestones in the Cretaceous rather than the pure Mississippian beds. The replacements appear to be controlled by certain faults and bedding so as to form chimneys. The occurrence is extremely erratic, and neither sizenor shape of individual ore shoots could be readily determined. Ore bodies were worked to the 900 level, and the total production was around 750,000 tons of 3.5 oz. Ag, 5% Pb, and 10% Zn.

At the San Xavier Extension mine a 6-foot limestone bed has been replaced to form an ore body of about 2500 tons of lead-zinc-copper-silver sulfide ore. Elsewhere in the district many small properties have been examined, and all just show weak and narrow mineralization, many as veins in volcanic rocks.

### Quijotoa District

A 4-foot fault zone in granite at the Dallas mine has pods of argentiferous galena with some copper. At the Five Metals mine oxidized lead-copper has been exposed along a fault zone that cuts intrusive rhyolite and an included block of limestone. A review of the district in 1950 concluded that the small vein deposits do not offer any encouragement for new exploration.

## PINAL COUNTY

### Bunker Hill District

Cretaceous sediments, including a 300-foot limestone member,and volcanic rocks have been intruded by Laramide granodiorite. The Cretaceous rocks have been sharply folded. Many faults,nearly all with small displacement, occur in four principal directions. Associated with the faults are over 100 breccia pipes. Copper and molybdenum are the main metals deposited in the breccia pipes, and the productive ones are either in or near the granodiorite.

Numerous veins crop out, and some show strong mineralization; but only the Blue Bird has been commercial. The vein occupies a fissure zone in granodiorite; it is from 2 to 5 feet wide and has been followed to slightly over 500 feet beneath the outcrop. Galena with several of the copper sulfides predominate; sphalerite is scarce. Copper increases with depth.

No mineralization seems to be found where the Cretaceous limestone either outcrops or may occur in depth; therefore, the only chance for exploration is the search for blind shoots.

### Cottonwood District

A report on the McWade-Durham property states that a quartz vein 8 feet wide and 300 feet long crops out in granite. Weak lead mineralization is found on the hanging wall for a width of 2 to 3 feet.

### Martinez Canyon District

The Silver Bell mine has been examined several times. A shear zone in Tertiary volcanic rocks localizes weak lead-fluorspar mineralization. Sampling

## PINAL COUNTY (Con't)

on the 200 level averaged less than 1% Pb and 5% fluorspar.

### Mammoth District

The Mammoth St. Anthony mine was an important source of oxidized lead-molybdenum-vanadium ores which at about 1100 feet changed to galena and sphalerite. When mining ceased in December, 1952, over 700,000 tons of sulfide ore had been mined. The property has been studied carefully by Asarco. It is now owned by San Manuel. One problem was pumping expense, but the deeper work at the San Manuel copper mine is said to have drained, at least in part, much of the mine. Our 1952 examination pointed to targets to 300 feet below the deepest, 1125, level that could find 175,000 tons of ore. The sulfide ore produced averaged about 6% Pb and 7% Zn. The ore occurs as space filling in fractures and brecciated areas.

### Ray (Mineral Creek) District

Various lead-zinc properties have been examined in past years. The Ajax mine has a quartz-calcite vein, 3000 to 4000 feet long, that strikes across Precambrian schist. On the 180 level about 200 feet of drift shows the vein to be 10 feet wide with very weak mineralization. The Ray Silver Lead mine was examined as recently as 1952. Replacements occur in Devonian limestone along premineral faults; some are as long as 1000 feet. The possibility of replacements in deeper limestones, some as deep as 600 feet, exists. Other mines are reported to have no merit.

### Superior District

The Fortune mine has produced argentiferous galena with some sphalerite from a vein in Precambrian diabase, but all the workings are caved. The Reymert mine is on a prominent vein outcrop 20 feet or more wide with a strike length of at least 6000 feet, and possibly twice that. The wall rock is Precambrian schist except at the north end where it cuts through a small diorite stock. The ore is essentially silver with low sulfide content; the gangue has 10% barite and some fluorite. The deepest work is 430 feet. This property could have some chance if the barite is a credit on the outcome.

### Saddle Mountain District

Narrow streaks and irregular bunches of lead-zinc with silver have been explored in various parts of the district. Some of the mineralization is in Cretaceous volcanics associated with quartz diorite dikes. As the limestones may be 1000 feet or more in depth, targets are remote. Where limestone is exposed, weak, spotty mineralization has been found.

## SANTA CRUZ COUNTY

### Harshaw and Patagonia Districts

In view of our former operations at the Trench and Flux mines, most of the district has been carefully examined and considered in past years; and exploration and mining has also been carried out by other companies. Many of the replacement bodies in Cretaceous limestone do not crop out, as at the Flux mine. Exploration at the Mowry mine by South American Development Co., however, was not successful.

## SANTA CRUZ COUNTY (Con't)

### Oro Blanco District

The ore bodies mined by Eagle Picher Company occur along a shear zone between intrusive diorite and a Cretaceous conglomerate; parallel shears with mineral are found in the conglomerate. The Montana vein on the surface is 3000 feet long and marked in part by bold quartz outcrops as wide as 50 feet. The mine was about 700 feet deep when it was abandoned in 1940. Much drilling had been done without success; one hole found quartz monzonite below the working 1000 feet. No other prospects for mines seem to exist in the district.

### Tyndall District

At the Baca Float Property a large number of small mines develop narrow veins containing argentiferous galena with some chalcopyrite and sphalerite. Three veins are 10 to 20 foot-wide quartz structures thousands of feet long, but ore is found only in short shoots. Reports indicate that prospecting has been extensive. The veins seem to be in intrusive and extrusive rocks. At the Isabelle mine small pockets of lead carbonate have been found in Permian limestone along a fault. At the Glove mine a pipe-like replacement body in limestone along a mineralized fissure has been mined to 360 feet, but its horizontal dimensions are only 10 by 30 feet. A band of silicified limestone 30 feet wide on the contact between intrusive quartz diorite and Devonian and Cambrian sediments is found at the Picnic mine; small amounts of low grade Pb-Zn-Cu-Ag have been found.

## YAVAPAI COUNTY

### Big Bug District

The main source of lead-zinc ores, with important values in precious metals, has come from the Iron King mine of Shattuck-Denn. The deposit is entirely in Precambrian rocks of the Yavapai schist; the ore occurs as massive sulfide in well defined veins. About a dozen veins have been productive; they range in width from 3 to 14 feet, up to 1000 feet long, and in 1960 had been developed to 2500 feet with drill holes to 3000 feet. The veins are en echelon in plan and in section so that many of the productive ones do not crop out. All the veins lie within a zone of hydrothermal alteration made up of chlorite and carbonate with some silicification and sericitization.

The combined ore shoots measure about 3500 feet long, and the production to date may be close to 5 million tons; the grade on the first million tons was about 0.13 oz. Au, 4.1 oz. Ag, 2.0% Pb, and 6.2% Zn.

The Golden Crown mine may lie along the northeast continuation of the Iron King structure, but thick gravel deposits conceal bedrock. The property was examined by Asarco but rejected because geophysical methods could not penetrate the thickness of gravels anticipated. Before our interest, several drill holes had been put down from the bottom of a 458 foot shaft through the gravels. Now the Hecla, Shattuck-Denn, and a uranium company have formed a joint venture so that Iron King workings can be used as a base for exploration.

The Arizona National mine has veins at or near the contact between Yavapai

YAVAPAI COUNTY (Con't)

schist and quartz diorite dikes. They average about 4 feet wide. Three drill holes were put down by New Jersey Zinc and Shattuck-Denn in 1950 and failed to cut any values.

The Leland-Dividend mine has veins about 5 feet wide in Precambrian schist and have been traced for several thousand feet; ore occurs in overlapping lenses in quartz veins. Other mines examined in the past include the Money Metals, Rebel-Kicker, UpShot, and Postmaster.

All the mineralization is considered to be of Precambrian age. Information available suggests that the Iron King improved with depth, and was, in fact, acquired in 1936 by tax sale. The Precambrian ore deposit at Pecos was similar in this respect. Possibly some of the other mines and prospects around Iron King require re-consideration; however, geophysics could play an important role.

Black Rock District

The Bunker Hill mine explores a vein along a wide fractured zone in Pre-Cambrian granite. Only small bunches of galena with values in gold and silver have been found; the gangue is a manganiferous calcite. Galena and sphalerite occur in small pockets in a narrow, short vein in Precambrian granite and an andesite dike at the Ari-Cal mine.

Black Hills District

The Prudential mine is also in Precambrian rocks that include schist. One quartz vein 4 feet wide by 1000 feet long contains minor amount of Cu-Pb-Zn; another 1½ feet wide by 300 feet long has a little cobalt.

Eureka (Bagdad) District

A narrow, persistant vein in Precambrian schist has been explored to at least 1000 feet of depth at the Hillside mine; in depth the vein lies along a 10-foot rhyolite dike. In 1942 the 900 level was sampled for 500 feet of length and averaged, over a width of 3.3 feet, 0.14 oz. Au, 3.6 oz. Ag, 1.2% Pb, and 4.1% Zn; but the total known strike length is 1800 feet.

Hassayampa District

The Ruth and Starlight mines seem to be similar; both are in Precambrian granite. The Ruth is reported to be a 6-foot fissure vein with high grade pockets of Ag-Pb-Au with 2000 feet of development. The Starlight is 1½ to 2 feet wide with lenticular shoots of Pb-Zn with good values in gold and silver.

Pine Grove and Tiger Districts

Many narrow quartz veins have been mined on, especially 50 years ago and earlier but largely for precious metals. The country rock is Precambrian schist intruded by granite and narrow rhyolite dikes; veins frequently follow the dikes. With depth the precious metal values decrease, and the base metal content is not enough to support a mining operation. Most veins are 3 feet or less in width,as at the Crown King mine. At the Tiger mine quartz diorite is reported, and vein widths of 7 to 25 feet have been noted in reports.

## YAVAPAI COUNTY (Con't)

### Turkey Creek District

This lies between Crown King mine and Iron King mine, but geological features are more like the former at the Mt. Union mine. Values occur in a narrow vein in spots and small lenses of Pb-Zn with good Au and Ag.

### Walker District

Again only Precambrian rocks are indicated on geological maps. The Poland mine adit cut at least 12 quartz veins that rarely attain 3-foot width with some galena and sphalerite plus precious metals. The Sheldon mine has a vein 3 to 4 feet wide in quartz diorite with levels as deep as 1250 feet; the approximate grade is 0.15 oz Ag, 8 oz. Ag, 1.5% Cu, 1% Pb, and 2% Zn.

## YUMA COUNTY

### Bouse District

The basal formation is Precambrian(?) gneiss which is overlain by limestone and in turn by silicified rhyolite. At the Southern Cross mine three fault breccia zones are cut by a 300 foot-long adit. All have scattered oxidized minerals and remnants of galena and sphalerite, with low precious metal content. The R & A mine explored a shoot 2 to 8 feet wide, 50 to 60 feet long, and 250 feet deep; a small amount of high grade oxidized silver-lead ore was shipped.

### Castle Dome District

Cretaceous(?) shale, impure cherty limestone, and clastic beds have been weakly metamorphosed, largely to schistose rocks; they rest unconformably on granite. Diorite porphyry and rhyolite porphyry dikes are numerous and form bold outcrops. Much of the area is covered by pediment gravels. Mineralization occurs in fault zones and is best where the wall, or walls, is diorite porphyry. The principal ore mineral is galena with less than 0.5 oz. Ag per 1% Pb. The gangue is fluorite and barite with some calcite and quartz; some fluorite has been mined. The average vein width is probably less than 5 feet, although locally they will expand. Much prospecting has been done beneath the gravel.

### Silver District

The main rock types are schist and granite cut by various types of dikes, including pegmatites, and volcanics. The volcanics, which overlie the schist and granite, are intruded by dikes from acid to basic composition. Mineralization is localized along pre-mineral faults. The Red Cloud mine explores a flat-dipping fault-vein between granite and volcanics to a vertical depth of nearly 400 feet. Two shoots with a combined maximum length of 200 feet were mined over widths of $1\frac{1}{2}$ to 6 feet. The ore was largely oxidized and valued for lead and silver, although zinc minerals occur. Included in the gangue minerals are fluorite, manganiferous calcite and quartz. Other mines are similar. The Yuma Metals did some diamond drilling under DMEA contract in 1953, but we have no information on the results.

## TEXAS

Except for the Terlingua quicksilver and the Shafter silver mines, very little non-ferrous metal mining has been done in Texas. Here and there around Van Horn small bodies have been exploited, such as the Plata Verde silver property and the Hazel silver-copper mine; and in the Shafter district some small lead ore bodies have been mined.

In the Llano-Burnet region there are small exposures of low grade lead mineralization in Cambrian sandstones and limestones having a total thickness of some 400-500 feet. The galena occurs as disseminated particles and in narrow fractures. The best mineralization is found at Silver Creek where sedimentary rocks dip outward from the exposed periphery of an exhumed knob of Precambrian granite. These deposits have been compared to the one in southeastern Missouri.

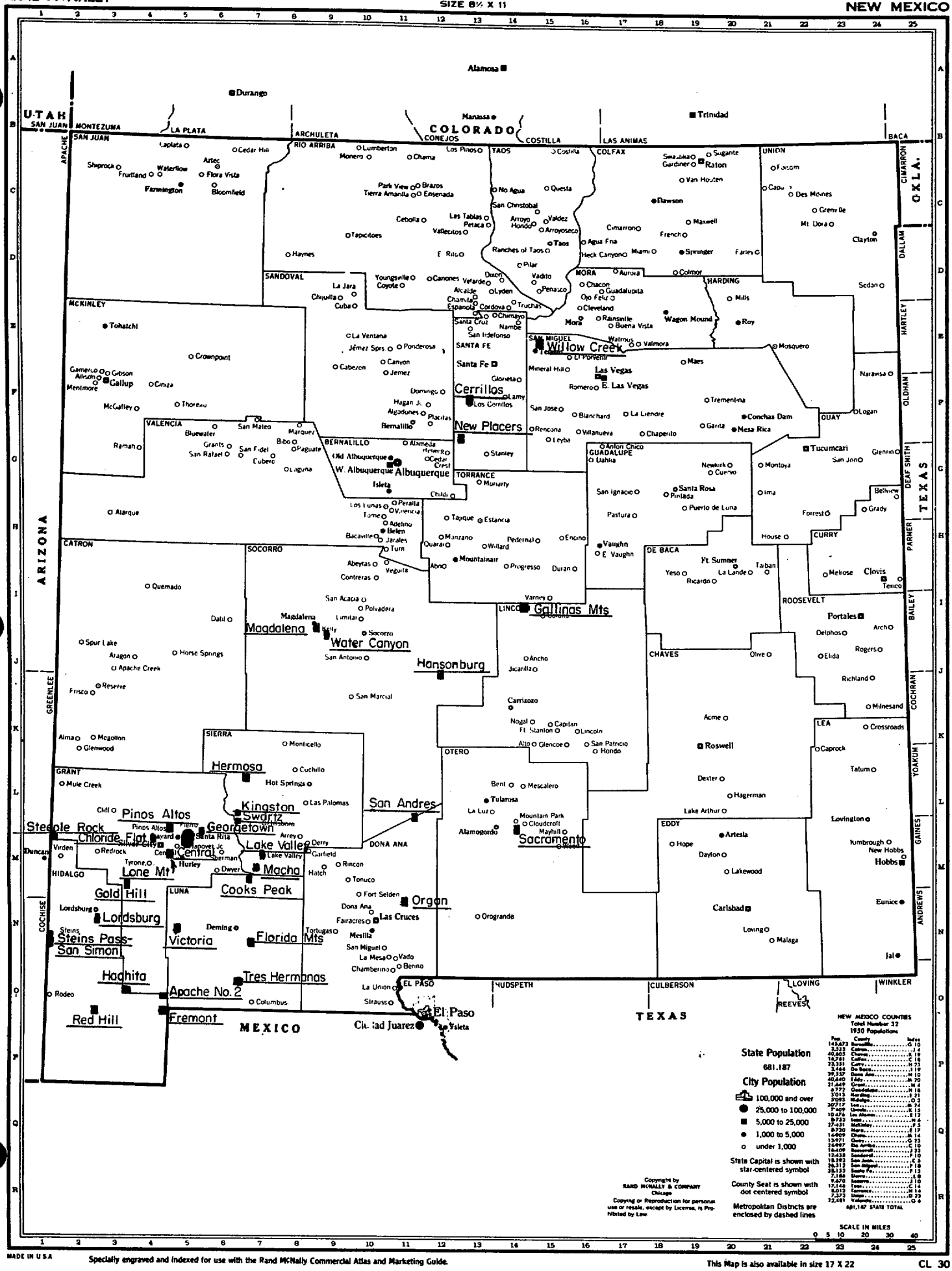
A small amount of lead concentrates were produced in a gravity mill that obtained its feed from shallow workings. Some churn drilling was done by Eagle Picher in 1925, but the results do not seem to be encouraging. Later some diamond drilling was done, but these results seem to be lost.

RAND McNALLY

# CITY-COUNTY STATE MAP

SIZE 8½ X 11

NEW MEXICO

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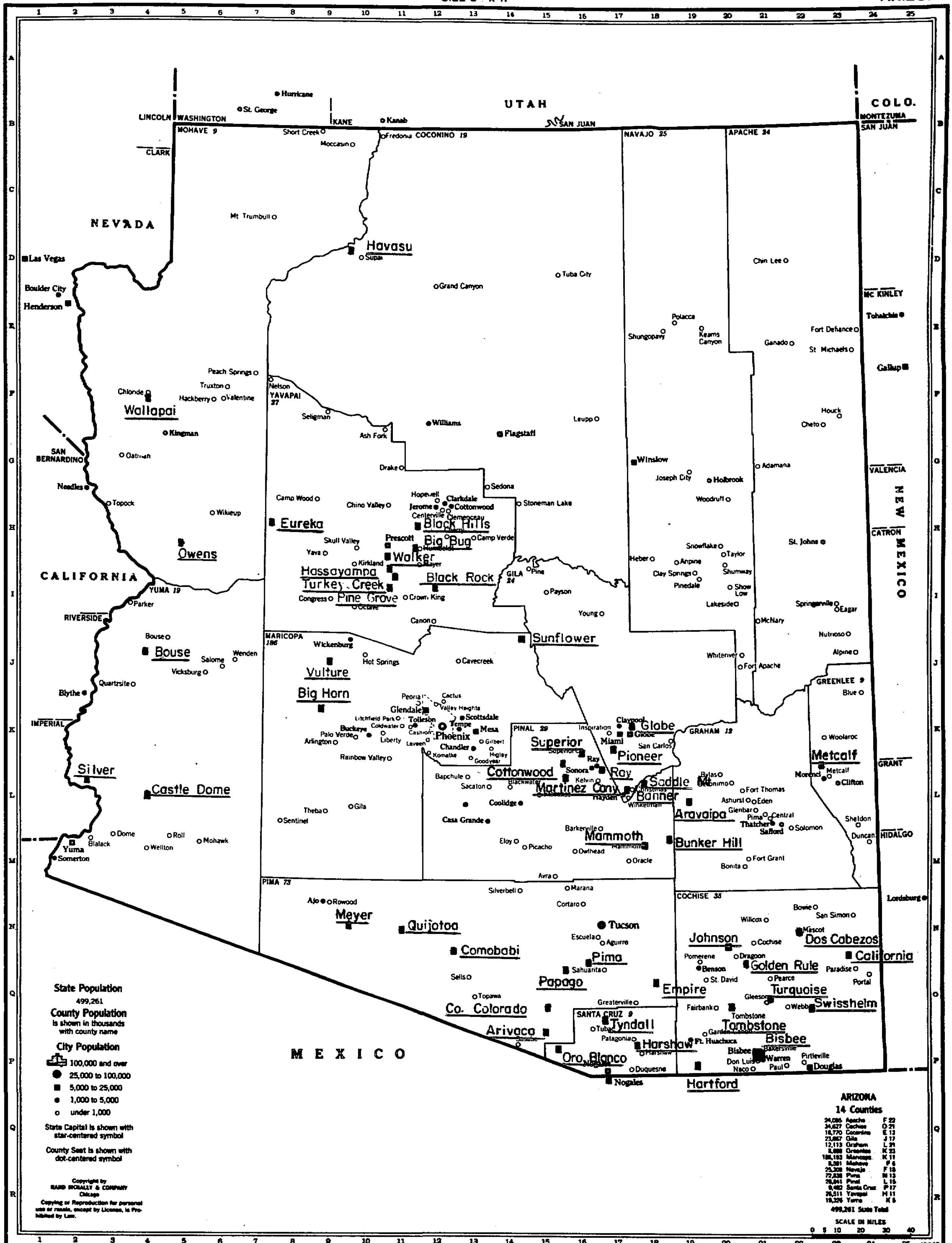
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NEVADA
CALIFORNIA
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COCONINO 19
NAVAJO 25
APACHE 24
YAVAPAI 27
GILA 24
MARICOPA 186
YUMA 19
PINAL 29
GRAHAM 12
GREENLEE 9
PIMA 73
SANTA CRUZ 9
COCHISE 35
LINCOLN
WASHINGTON
KANE
SAN JUAN
MONTEZUMA
CLARK
SAN BERNARDINO
RIVERSIDE
IMPERIAL
MC KINLEY
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HIDALGO
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Needles
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Prescott
Phoenix
Tempe
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Scottsdale
Chandler
Casa Grande
Globe
Miami
Winslow
Holbrook
St. Johns
Tucson
Nogales
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Douglas
Gallup
Lordsburg
Havasu
Wallapai
Owens
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Silver
Castle Dome
Eureka
Black Hills
Big Bug
Walker
Hassayampa
Turkey Creek
Pine Grove
Black Rock
Sunflower
Vulture
Big Horn
Superior
Pioneer
Cottonwood
Ray
Martinez Cany
Saddle Mt.
Banner
Aravaipa
Mammoth
Bunker Hill
Metcalf
Meyer
Quijotoa
Comobabi
Pima
Papago
Empire
Co. Colorado
Arivaca
Oro Blanco
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