NEW MEXICO SCHOOL OF MINES

STATE BUREAU OF MINES AND
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President and Director

BULLETIN NO. 7

The Metal Resources of New Mexico and Their Economic Features

BY

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THE STATE BUREAU OF MINES AND MINERAL RESOURCES

The State Bureau of Mines and Mineral Resources of New Mexico was established by the New Mexico Legislature of 1927. It was made a department of the New Mexico School of Mines, and its activities are directed by the board of regents of the school. Its chief object is to assist and encourage the development of the mineral resources of the State.

BOARD OF REGENTS

PUBLICATIONS

Bulletin No. 1. The Mineral Resources of New Mexico—Fayette A. Jones, 1915. (Out of print.)

Bulletin No. 2. Manganese in New Mexico—E. H. Wells, 1918. (Out of print.)

Bulletin No. 3. Oil and Gas Possibilities of the Puertecito District, Socorro and Valencia Counties, New Mexico—E. H. Wells, 1919. (Out of print.)

Bulletin No. 4. Fluorspar in New Mexico—W. D. Johnston, Jr., 1928. (Price 60 cents.)

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Bulletin No. 6. Mining and Mineral Laws of New Mexico—C. H. Fowler, 1930. (Price 25 cents.)

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Bulletin No. 8. The Ore Deposits of Socorro County, New Mexico—S. G. Lasky, 1932. (Price 60 cents.)

Bulletin No. 9. The Oil and Gas Resources of New Mexico—Dean E. Winchester, 1933. (Price $1.50.)

NOTE.—Bulletins 1, 2 and 3 were issued by the Mineral Resources Survey of the New Mexico School of Mines.

The Metal Resources of New Mexico and Their Economic Features

By

SAMUEL G. LASKY *and* THOMAS PELTIER WOOTTON

PART I. INTRODUCTION

PURPOSE AND SCOPE OF BULLETIN

In this bulletin an attempt has been made to assemble information of particular value to those interested in developing and working the metalliferous deposits of New Mexico. All known districts in the State are briefly described. History, production and geology are given in variable detail in these descriptions, depending upon the importance of the district, and a section of the bulletin contains a catalogue of the occurrence and distribution of the metallic minerals found in the State. Special attention has been given to the economic features of the metals and minerals, and separate sections are devoted to the production and uses of the metals and to the marketing of the different ores. The novice and those of limited mining experience will find Part V. of the bulletin, entitled "Economic Features of Prospecting, Mining and Milling," of special interest.

The placer deposits of New Mexico received much attention during 1931 and 1932, and both large and small operations were begun in a number of districts. Because of the fact that most of this report was prepared prior to 1932, it has not seemed feasible to discuss the recent placer operations in detail.

OTHER REPORTS DEALING WITH THE GEOLOGY AND MINERAL RESOURCES OF NEW MEXICO

The mineral resources of New Mexico have been described by several writers. A volume entitled "New Mexico Mines and Minerals," by Fayette A. Jones, was published in 1904, but the first comprehensive description of the ore deposits of the State was the report of Lindgren, Graton and Gordon,[1] "The Ore Deposits of New Mexico," issued in 1910. A report by James M. Hill, "Mining Districts of the Western United States,"[2] published in 1912, contains a section on New Mexico, including a map of the State showing the location of each mining district and

[1] Lindgren, Waldemar, Graton, L. C., and Gordon, C. H., U. S. Geol. Survey Prof. Paper 68, 1910.
[2] U. S. Geol. Survey Bull. 507, 1912.

noting its predominant metal. This map is accompanied by text information giving for each camp a full list of the metals produced, the shipping point for the camp and a simple statement of the geologic formation and kind of deposit. In 1917 the United States Geological Survey published a bulletin entitled "Useful Minerals of the United States,"[1] which, among other features, gives concisely the location by States and counties of the principal deposits of the useful minerals, and which affords a valuable supplement to Hill's report. The New Mexico School of Mines published a short report by F. A. Jones entitled "The Mineral Resources of New Mexico,"[2] in 1915. Unfortunately all the foregoing publications are now out of print and not available to the general public except through public and semipublic libraries. The annual volumes of "Mineral Resources of the United States," published until 1923 by the United States Geological Survey and since then by the United States Bureau of Mines, consist mainly of statistics of production and market conditions, but they also contain occasional geologic descriptions. In 1930 the University of New Mexico published a bulletin called "New Mexico Mineral Deposits Except Fuels"[3] which covers briefly both metallic and non-metallic deposits except oil, gas and coal.

The best general description of the geology of New Mexico is contained in two bulletins by N. H. Darton, entitled, "'Red Beds' and Associated Formations in New Mexico, with an Outline of the Geology of the State,"[4] and "Geologic Structure of Parts of New Mexico."[5] Darton's geologic map of New Mexico, published by the United States Geological Survey in 1928, on a scale of 1:500,000, is invaluable to students of the geology of the State.

Bulletin No. 5 of the New Mexico Bureau of Mines and Mineral Resources entitled "Geologic Literature of New Mexico," by T. P. Wootton, contains a complete bibliography on this subject, including a list of maps. All the literature pertaining to the mineral resources of the State is listed therein and indexed under the head of "Economic Geology."

ACKNOWLEDGMENTS

This bulletin is chiefly a compilation. Unless otherwise noted, all production statistics have been compiled from the annual volumes of "Mineral Resources of the United States." Geologic summaries have been abstracted chiefly from publications of the United States Geological Survey and of the New Mexico Bureau of Mines and Mineral Resources, and current scientific and technical periodicals have been freely consulted. Certain

[1] Schrader, F. C., Stone, R. W., and Sanford, Samuel, U. S. Geol. Survey Bull. 624, 1917.
[2] Jones, F. A., N. Mex. Sch. of Mines, Min. Res. Survey, Bull. 1, 1915.
[3] Ellis, R. W., Univ. of N. Mex. Bull. 167, 1930.
[4] U. S. Geol. Survey Bull. 794, 1928.
[5] U. S. Geol. Survey Bull. 726, pp. 173-275, 1922.

districts concerning which no recently published data are available were visited by Mr. Lasky. These are the Sacramento district, Otero County; Little Florida Mountains, Luna County; White Signal district, Grant County; and the Ground Hog mine and vicinity, Central district, Grant County. Professional Paper 68 of the United States Geological Survey has been used as a general reference, and much of the geologic and historical information appearing in this report has been summarized from it. More recent information has been suitably acknowledged.

In the preparation of this report, T. P. Wootton handled the compilation of nearly all the production statistics and assisted in the preparation of the maps and charts. The sections of Part V. entitled "Mining," "Milling" and "General Economic Features" were prepared by G. T. Harley. The rest of the bulletin was prepared by S. G. Lasky.

Thanks are due to those who permitted examination of their properties for this report, namely, J. W. Ady, Jr. of Alamogordo, R. H. West of Deming, Otto Forster of White Signal, and the Asarco Mining Co. of Vanadium; also to the Phelps Dodge Corp., Calumet & Arizona Mining Co., Peru Mining Co., Manganese Valley Mines Co., and the United States Mint, Denver, Colorado, for considerable information used in the chapter on marketing.

PART II. HISTORICAL REVIEW

Lindgren[1] has described the early history of mining in New Mexico as follows:

> Unlike the more northerly States, New Mexico was at the time of the discovery of America settled by tribes of semicivilized Pueblo Indians, who lived in well-constructed cities and who practiced agriculture by the aid of irrigation. Mining was not extensively developed among them, but they knew the value of turquoise, which occurs in various places in the Territory and which was used by them for ornaments and probably also in some way as money. There is also some evidence that they used gold for ornaments and that they probably obtained some of it from placers within the region. The first white man who set foot in the Territory is believed to have been Alvar Nuñez Cabeza de Vaca, who reached it from the East in 1534. An expedition headed by Coronado explored the northern part of the Territory in 1540 and 1541. Between 1580 and 1680 the Indians were converted to Christianity by Spanish monks, and a number of missions were established.
>
> The early Spanish explorers speak of turquoise as being obtained in the country, and it is now a generally accepted belief that the quarries containing turquoise in the Los Cerrillos Hills were worked prior to the advent of the Spaniards. There is also some evidence that the turquoise mines of the Burro Mountains and the Hachita Range were similarly worked at a very early date. The early missions were established principally by the Jesuits, and it is believed that some mining was done by the Indians under their direction. It is thought that gold was obtained from the gravels near Taos, and there is some evidence of early attempts to open silver mines. Traces of such ancient mining for silver are found in the Los Cerrillos district, at a prospect near Ojo Caliente, and possibly also in the Hachita Range. The evidence is, however, not conclusive.
>
> In 1680 the Pueblo Indians revolted against the oppressive rule of the Jesuits, and the Spaniards were obliged to abandon the country, returning, however, about twenty years later. It is stated that on their return it was expressly stipulated by the Indians that the Spaniards should not again engage in mining, but only in agricultural pursuits. At any rate, little mining was done during the eighteenth century. F. A. Jones[2] mentions a document found in Santa Fe under date of 1713, which refers to an old covered-up mine in the "Sierra de San Lazora." About the end of the eighteenth century the copper mines at Santa Rita, in the southwestern part of the Territory, were discovered, and they are said to have had a large production for a time. It is worthy of note that these mines have been almost continuously worked up to the present day.

The first systematic mining by white men in New Mexico was at the copper deposits at Santa Rita. These mines were the site of the earliest underground mining of copper in what is now the United States, with the exception of the native copper deposits in the Lake Superior region. According to tradition, the Apaches mined and utilized the native copper of the Santa Rita deposits in the seventeenth century. In 1800 an Indian showed the deposits to a Spanish officer in return for some kindness that had been rendered, and in 1801 shipments of copper were started to Chihuahua, Mexico, and to Mexico City. This production is said to have consisted of as much as 20,000 mule loads, or 4,000,000 pounds, per annum during the early part of the century. The mines passed through a number of hands and yielded a moderate

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[1] Lindgren, Waldemar, Graton, L. C., and Gordon, C. H., The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, p. 17, 1910.

[2] New Mexico mines and minerals, p. 13, 1904.

production until the organization of the Chino Copper Co. in 1909. Steam-shovel mining was instituted by this company and extensive production was begun in 1912. Since then the Chino mines have consistently accounted for the major part of New Mexico's copper production. The property was acquired in 1924 by the Ray Consolidated Copper Co. of Arizona, which in 1926 became a part of the Nevada Consolidated Copper Co. The Santa Rita copper mines are now known as the Chino mines of the Nevada Consolidated Copper Co.

Gold was discovered in New Mexico in 1828 at the Old Placers in the Ortiz Mountains south of Santa Fe, Santa Fe County. This is the first authentic record of placer mining in the United States west of the Mississippi River, and Jones[1] states that this discovery constituted the initial impulse toward development of the West. The discovery of the Old Placers was made twenty years before the first gold excitement in California and thirty years before the first discoveries in Colorado. Gold-quartz veins were discovered near the Old Placers in 1833, and in 1839 the rich New Placers in Santa Fe County were discovered.

Lead ore was found in the Organ Mountains in 1849, and for several years a small production was maintained, but here as elsewhere operations were seriously handicapped by the hostility of the Indians. Gold placers were discovered at Pinos Altos, about 12 miles northwest of Santa Rita, Grant County, in 1859 or 1860, and vein deposits were discovered there a few months later. Prospectors were soon forced to leave, however, by the Indians. Practically all mining work in the Territory was suspended during the Confederate invasion under General Sibley in 1861 and 1862. Mining was resumed in several districts in 1863, but in the Pinos Altos district this was delayed until 1867.

In 1863, a soldier by the name of Pete Kinsinger is said to have found rich silver ore while stationed at Pueblo Springs near Magdalena, Socorro County. This is recorded as the first silver discovery in the State. The lead-silver deposits of the Magdalena district were found three years later by J. S. Hutchason while hunting for Kinsinger's discovery. A year later, in 1867, prospectors spreading out from Magdalena found silver veins in the Socorro Peak district. At about the same time placer gold was found in the Elizabethtown district in Colfax County by prospectors from Colorado.

The construction of the Southern Pacific and the Atchison, Topeka & Santa Fe railway lines through New Mexico was followed by a period of important mining activity. Lindgren, in Professional Paper 68 of the U. S. Geological Survey (p. 18), describes this period as follows:

[1] Jones, F. A., The mineral resources of New Mexico: N. Mex. Sch. of Mines, Min. Res. Survey Bull. 1, p. 9, 1915.

The surveying and construction of the Southern Pacific Railroad and the Atchison, Topeka, and Santa Fe Railway through the central and southern parts of the Territory, from 1879 to 1882, brought a large number of prospectors and miners. This was an epoch of great activity. Practically all the mining districts now [1910] worked were then discovered and developed. It was essentially an epoch of silver mining; copper and the other base metals were little sought for, and even gold was less considered than silver. A great number of mills and small smelters were erected; many of the latter were built at inconvenient places and operated on unsuitable ores without much metallurgical knowledge. Rich silver ores were discovered, milled, or smelted at Silver City and Georgetown; and it is reported that over $3,000,000 in silver was obtained in a short time at Chloride Flat near Silver City. Stamp mills were built at Pinos Altos. Rich silver lead ores were extracted from the Victorio district near Deming. Many new discoveries were made in the Mimbres Mountains, or Black Range, for many years haunted by hostile Indians. In 1877 placers and gold quartz-veins were found near Hillsboro, and during the few following years the Hermosa, Kingston, Apache, and Cuchillo Negro districts were prospected and a considerable amount of silver ores extracted.

In 1878 were found the phenomenally rich silver mines of Lake Valley, which in a few years yielded a total of 5,000,000 ounces of silver, but which were soon worked out. The Mogollon Mountains, in * * * [Catron] County, close to the Arizona line, contain one of the richest districts of the Territory, though one of the most difficult of access. This vicinity, now known as the Cooney district, was first prospected in 1875, but not until about twenty years later was much progress made in the mining and reduction of the rich gold and silver ores. Small lead smelters were built at Socorro, Los Cerrillos, Hachita, and a number of other places. The Socorro plant was built [in 1881], and in 1887 another lead smelter was erected at El Paso, Tex.

As noted above, deposits discovered in this period were mined chiefly for their silver content. Most of them consisted of oxidized ores near the surface, and these were soon exhausted. The gradual fall in the price of silver from $1.07 per ounce in 1885 to below 60 cents in the final years of the nineteenth century resulted in the closing of many of the mines.

The increased demand for the base metals which developed at the beginning of the present century injected new life into the mining industry, and ores of these metals began to be sought. The smelters at Socorro, N. Mex. and El Paso, Tex., were acquired by the American Smelting & Refining Co., who dismantled the Socorro plant and enlarged the one at El Paso to permit handling copper ores. The copper smelter at Douglas, Ariz., was built in 1902. These smelters provided a market for base-metal ores of the State and stimulated prospecting.

In 1903 high-grade zinc ores were discovered associated with the lead ores of the Magdalena district. This district was for many years the chief producer of zinc in the State. In 1905 production of zinc ore began in the Central and Pinos Altos districts, Grant County, and since then zinc has represented an important part of the State's metal output. The Hanover district, Grant County, did not become an important producer of zinc, until 1910, although zinc ore had been mined there since 1891 or earlier. The important zinc mines in this district are owned by the Empire Zinc Co.

The low-grade copper deposits of the Burro Mountains district were discovered in 1900 and yielded moderate amounts of copper for several years. The Phelps Dodge Co., now the Phelps Dodge Corp., entered the district in 1905. Some years later a large tonnage of low-grade ore was developed by this company, and a concentrating mill with a capacity of 2,000 tons per day was constructed. An important production was maintained from 1916 to 1921 when the mines were closed. Considerable blocked-out ore remains in the ground.

The Lordsburg district, discovered in 1870, has been an important producer of copper since 1920, due chiefly to the operations of the Calumet & Arizona Mining Co. at the Eighty-five mine. This mine was acquired by the Phelps Dodge Corp. in 1931.

In recent years base-metal ores have become an important source of gold and silver in New Mexico, but appreciable quantities of precious-metal ores have been sporadically produced at the Aztec mine of the Maxwell Land Grant Co. in the Elizabethtown district, Colfax County, and in the Mogollon district, Catron County, where the Mogollon Mines Co., now defunct, was the chief company. Large-scale operations in the Mogollon district were suspended in 1925.

The Pecos mine at Tererro, San Miguel County, was discovered in 1883. It was acquired by the American Metal Co. of New Mexico, a subsidiary of the American Metal Co., Ltd., in 1925, and a modern concentrating mill was constructed. Large-scale operations began late in 1926. In 1927 this mine became and has continued to be the largest individual producer of zinc, lead, gold and silver in New Mexico. In 1928 a large body of complex ore was discovered at the Ground Hog mine in the Central district, Grant County, and this mine has yielded important amounts of zinc, lead, copper and silver. A controlling interest in the mine was acquired in 1928 by the Asarco Mining Co., a subsidiary of the American Smelting & Refining Co.

The iron mines at Fierro, Grant County, had their first recorded production in 1891. They were worked almost continuously from 1899 to 1931, except in 1904 and a part of 1907-1908 when operations were suspended on account of labor difficulties. The Hanover Bessemer Iron & Copper Co., which is controlled by the U. S. Smelting, Refining & Mining Co., is the chief producer. Deposits at Boston Hill near Silver City, Grant County, have yielded manganiferous iron ore intermittently since the nineties. Numerous manganese deposits were worked during the World War, but only a moderate amount of ore was produced and none of the properties which were active at that time developed into large mines. A large manganese deposit has been developed in the last few years in the Little Florida Mountains, Luna County, and from it has come a large part of the high-grade manganese ore mined in New Mexico.

The molybdenum deposits of the Red River district, Taos County, were recognized in 1917. These deposits were worked for a brief period by the R. & S. Molybdenum Co. and were acquired in 1920 by the Molybdenum Corporation of America. A concentrating mill was built, and the property has become the second largest producer of molybdenum in the United States.

Mining in general in the State was stimulated greatly by World War conditions and was phenomenally prosperous from 1916 to 1918. The country-wide depression of 1921 closed most of the mines, and the value of the State's production for that year was the lowest it had been since 1912. The industry recovered rapidly in 1922 and 1923 and there was a steady expansion until the beginning of the current depression in 1929. The zinc and iron mines of the Hanover-Fierro district suspended operations in 1931, and the Eighty-five mine at Lordsburg was shut down and the pumps drawn in January, 1932, shortly after the mine was acquired by the Phelps Dodge Corp. With the exception of the Pecos mines of the American Metal Co., the base-metal mines that were operating in 1932 were doing so at greatly reduced capacity. As the period of economic depression became prolonged, attention was diverted from base metal to gold mining. The older gold producing districts, both lode and placer, are being reexamined and activities have been resumed or increased in some of them, and an active search is being made for new deposits.

PART III. METAL RESOURCES OF NEW MEXICO

SUMMARY OF GEOLOGY AND ORE DEPOSITS

A short, graphic description of the geology and ore deposits of New Mexico by Waldemar Lindgren appears in the report by Hill[1] entitled "Mining Districts of the Western United States." This description is given below, supplemented by a number of revisions and additions in brackets [ ], by S. G. Lasky:

The ore deposits of New Mexico form a gradually widening belt extending through the central portion of the State from Colfax County, at the north, to the southwest corner; in this southern part the districts are scattered over a wide area between El Paso and Silver City. * * * Gold, silver, copper, lead, and zinc are the principal metals of the output, and Grant, [San Miguel, and Hidalgo] are the principal productive counties.

New Mexico contains several well-defined geologic provinces. Over the smaller eastern portion extend high plains or plateaus of horizontal or gently dipping Tertiary, Cretaceous, [Triassic] and Carboniferous sediments. About the middle of the State these almost connect with the similar strata of the plateau province which cover the northwestern part, their monotony being broken only by several minor uplifts like the Zuñi Mountains.

Through the center of the State and trending north and south are a succession of ranges. Toward the Colorado boundary they are high and assume the type of the Rocky Mountain uplifts, with a central core of pre-Cambrian rocks surrounded by the upturned edges of Paleozoic and Mesozoic strata. Toward the south they are lower and are of the monoclinal type of the Basin Ranges, being limited on the east or west side by prominent faults. The pre-Cambrian is less prominently exposed and the sediments comprise a thick series. In the central [and southern] parts of the State a thin bed of Cambrian quartzite is covered by [several] hundred feet of Ordovician [limestone], 200 feet of Devonian shale, [up to 200] feet of Mississippian, [from 900 to 2,000] feet of Pennsylvanian limestone and [shale], and [by Permian "Red Beds" and limestone which reach a thickness of over a mile in eastern New Mexico]. Above this lies a small thickness of [Triassic and locally Jurassic] strata, and these are in turn covered by [remnants] of Cretaceous coal-bearing sandstones and shales [up to 2,000 feet thick]. [Triassic, Cretaceous and Tertiary rocks are the surface rocks of most of the northeastern part of the state]. The southwest corner of New Mexico is occupied by a number of low ranges of the Arizona type, trending north-northwest, separated by wide desert plains and built up of folded and faulted Paleozoic and Mesozoic sediments [and Tertiary rocks]; these ranges rarely have pronounced monoclinal structure. Lavas of late Tertiary age, chiefly andesitic and rhyolitic, cover a large space in the southwest, separating the province of the desert ranges from the plateau province. These lavas also extend toward the northeast and occupy large areas north of Santa Fe, but are here mainly basalts of * * * Quaternary age. Minor intrusions of quartz monzonites [generally] of late Cretaceous or early Tertiary age are known in nearly all the ranges and follow closely in their distribution the trend of the main mineral-bearing districts. [Some of these intrusions are later than a part of the lavas].

Deposits of pre-Cambrian age are known to occur in the northern ranges in Colfax, Taos, and Rio Arriba counties. [Zinc], copper, and gold are the principal metals. The deposits form either lenticular quartz veins or disseminations [and fillings] of sulphides in [sheared] basic igneous rocks. At the Hamilton mine,[2] in the Pecos district, Carboniferous strata

[1] Hill, James M., U. S. Geol. Survey Bull. 507, pp. 33-35, 1912.
[2] Now the Pecos mines of the American Metal Co. of New Mexico.

cover the decomposed outcrops of a [zinc] deposit of the latter kind. Many of the deposits contain minerals like garnet, tourmaline, and amphibole. The principal [localities are the Pecos district in San Miguel County] and the Hopewell and Bromide districts, in Rio Arriba County, where veins of this kind * * * have been mined.

In New Mexico, as elsewhere in the Western States, the most abundant deposits are those which were formed at the end of the Cretaceous or in the earliest Tertiary and which stand in close connection with granite or monzonite intrusions, surrounding them like metallic aureoles. There are several subdivisions of this genetic class which yield ores of gold, silver, copper, lead, and zinc.

Contact-metamorphic deposits in the silicate zone between limestone and intrusive rocks are more abundant than in any of the other States except possibly Arizona. They carry copper ores in the Elizabethtown, San Pedro, Organ, Jarilla, Hanover, [Magdalena], and Hachita districts; lead and zinc ores are developed in the Magdalena and Tres Hermanas districts; iron ores at Hanover, Jones Camp, and other places. [At least fourteen] districts with such ores are known. Magdalena, San Pedro, and Hanover have yielded a considerable production of base metals.

Quartz veins almost invariably accompany the intrusions and are chiefly of the gold-bearing pyritic type, though in places they also carry silver, lead, and copper. The principal producing districts of this kind are Elizabethtown, Ortiz, White Oaks, and Pinos Altos. The silver veins form a smaller group, most of them occurring in Grant County. Replacement deposits of argentiferous galena or silver ores are found at some little distance from the intrusive contact and have been mined in the Organ, Hermosa, Kingston, Hillsboro, Lake Valley, Georgetown, Victorio, Chloride Flat, and Granite Gap districts. [Copper-tourmaline deposits occur in the Lordsburg district.]

In connection with this general type of mineralization near intrusive bodies, there are at a few places, such as the Burro Mountains and Santa Rita in Grant County, disseminations of cupriferous pyrite which are too poor to mine in themselves, but which have been enriched by a Recent or late Tertiary deposition of chalcocite formed by descending waters. These deposits now form large bodies of low-grade copper ore which are the main source of the copper production of the State.

Placer deposits [some of] which formerly were highly productive are [sporadically] worked at Elizabethtown, in Colfax County, in the Ortiz and San Pedro Mountains, at Hillsboro, at Pinos Altos, [in the Jicarilla Mountains, Lincoln County, and at Orogrande, in Otero County]. Most of them are derived from veins of early Tertiary age.

A distinctly later mineralization than that described above developed in some places in the lavas of middle or late Tertiary age, shortly after their eruption. It produced quartz veins carrying chiefly gold and silver and with certain characteristics indicating deposits near the surface. The principal districts are at Cochiti, in Sandoval County; at Hillsboro and in the Black Range, in Sierra County; and in the Mogollon district, in [Catron] County. * * *

Concentrations of chalcocite in the sandstones of the "Red Beds" of Triassic or late Carboniferous age are found at Tecolote and other places in San Miguel County; in the Nacimiento and Zuñi Mountains, in the northwestern part of the state; at Estey, in Lincoln County; at Tularosa, in Otero County; [near Scholle, in Valencia County; at Pastura, in Guadalupe County]; and at several other places. [Lead mineralization also occurs in the "Red Beds."][1] The origin of these copper ores is still under discussion * * *. The deposits are in general independent of igneous rocks.

The iron ores consist chiefly of magnetite, occurring in contact-metamorphic deposits. They have been mined at Fierro [and near Santa Rita], in Grant County. A bed of limonite in Cretaceous strata has also been

[1] Lasky, S. G., The ore deposits of Socorro County, New Mexico: N. Mex. Sch. of Mines, State Bur. of Mines and Min. Res. Bull. 8, pp. 133-137, 1932. Also see page 86, this bulletin.

mined near Glorieta, in Santa Fe County, [and manganiferous iron ore has been mined at Boston Hill, in Grant County].

Bismuth ores occur in the San Andreas Range. Vanadium ores occur near Hillsboro and in the Caballo Range; [at Vanadium, Grant County; and near Magdalena, Socorro County].

The following statements supplement the above quotation from Hill's report: Tungsten minerals occur at a number of places, notably in the Victorio district, Luna County; the White Oaks district, Lincoln County; and the Apache No. 2 district, Hidalgo County. A fairly large body of molybdenum ore, chiefly molybdenite, is being mined in the Red River district, Taos County. Molybdenum minerals occur as accessory constituents of other ores at a number of places. Cobalt and nickel occur in silver ore in the Black Hawk district, Grant County. Tin deposits with associated placers have been found in rhyolite in the Taylor Creek district, in Catron and Sierra counties. Several kinds of manganese ore have been mined, chiefly in Dona Ana, Grant, Luna, Sierra and Socorro counties. Antimony and arsenic occur chiefly as subordinate constituents of other ores. Stibnite has been mined in the Hachita district, Grant County. Ore containing radium and uranium has been mined in the White Signal district, Grant County.

OCCURRENCE AND DISTRIBUTION OF NEW MEXICO ORE MINERALS

The known ore minerals of New Mexico are listed on the following pages, alphabetically arranged under the different metals. The mineralogic and common names, chemical composition, and geographic distribution by counties and districts are noted.

The chemical symbols of the metals and other elements which unite in different combinations to form the ore minerals are as follows:

ELEMENT	*SYMBOL*	*ELEMENT*	*SYMBOL*
Aluminum	Al	Manganese	Mn
Antimony	Sb	Molybdenum	Mo
Arsenic	As	Nickel	Ni
Barium	Ba	Niobium	Nb
Bismuth	Bi	Nitrogen	N
Bromine	Br	Oxygen	O
Cadmium	Cd	Phosphorus	P
Calcium	Ca	Potassium	K
Carbon	C	Silicon	Si
Chlorine	Cl	Silver	Ag
Cobalt	Co	Sulphur	S
Columbium	Cb	Tantalum	Ta
Copper	Cu	Tellurium	Te
Gold	Au	Tin	Sn
Hydrogen	H	Tungsten	W
Iodine	I	Uranium	U
Iron	Fe	Vanadium	V
Lead	Pb	Zinc	Zn

ANTIMONY

Antimony minerals are known in New Mexico chiefly as accessory constituents of other ores. Antimony is an undesirable constituent of a smelting ore and should be removed by milling if possible before the ore is shipped.

Bournonite. See under copper minerals.

Cervantite. Antimony trioxide and pentoxide ($Sb_2O_3 . Sb_2O_5$). Grant County, Central district.

Polybasite. See under silver minerals.

Stibnite (antimony glance). Antimony sulphide (Sb_2S_3). Grant County: Hachita district, with silver ores; reported near Santa Rita. Santa Fe County, Cerrillos district. Taos County, Twining district (?).

Stephanite. See under silver minerals.

Tetrahedrite. See under copper minerals.

ARSENIC

The general remarks concerning the occurrence of antimony apply also to arsenic. It is produced chiefly by copper smelters as a by-product from arsenical copper ores.

Annabergite. See under nickel minerals.

Arsenopyrite (mispickel). Sulfarsenide of iron (FeAsS). Santa Fe County, Old Placers district, reported. Hidalgo County, Lordsburg district, reported.

Domeykite. See under copper minerals.

Erythrite. See under cobalt minerals.

Enargite. See under copper minerals.

Mimetite. See under lead minerals.

Niccolite. See under nickel minerals.

Pearceite. See under silver minerals.

Proustite. See under silver minerals.

Chloanthite-smaltite. See under nickel minerals.

Stromeyerite. See under silver minerals.

Tennantite. See under copper minerals.

Xanthoconite. See under silver minerals.

Arsenic occurs in the lead-silver ores of the Victorio district, Luna County; in the Hachita district, Grant County; in the San Simon district, Hidalgo County; and in the copper-silver ores of the Jicarilla district, Lincoln County; but its mineral combination at these places is unknown. Copper arsenates of undetermined composition occur in the Hansonburg district, Socorro County.

BISMUTH

Bismuth (native). An element (Bi). Dona Ana County, Organ district, at places in commercial quantities, associated with other ores. Grant County, Big Burro Mountains, reported. Luna County, Fremont district, rare with silver ores. Socorro County, Grandview district, rare, with bismuth ores.

Bismuthinite (bismuth glance). Bismuth sulphide (Bi_2S_3). Dona Ana County: Organ district, associated with copper-silver ores in workable quantities; Gold Camp, in quartz-pyrite veins. San Miguel County, El Porvenir district, with molybdenum and tungsten minerals. Socorro County, Grandview district, San Andres Mountains, mined with other bismuth minerals and scheelite.

Bismutite. Basic bismuth carbonate ($Bi_2O_3 . CO_2 . H_2O$). Socorro County, Grandview district. Grant County, Big Burro Mountains. Probably accompanies every occurrence of bismuth minerals, of which it is an oxidation product.

Tetradymite. Bismuth telluride (Bi_2Te_3). Colfax County, Baldy district, with gold ores. Hidalgo County, Sylvanite district, with free gold. Sierra County, Hillsboro district, rare.

Bismuth has been recovered from ores of the Apache No. 2 district, Hidalgo County, but the mineralogy is not known.

CADMIUM

The usual occurrence of cadmium is in greenockite associated with certain minerals in zinc deposits.

Greenockite. Cadmium sulphide (CdS). Grant County, reported from Pinos Altos district. Socorro County, Magdalena district, in very minor quantity with smithsonite.

COBALT

Erythrite (cobalt bloom). Hydrous cobalt arsenate ($Co_3As_2O_8 . 8H_2O$). Grant County, Black Hawk district, with silver ores.

Chloanthite-smaltite. See under nickel minerals.

COPPER

Copper minerals occur, at least in traces, in nearly every district in New Mexico.

Aurichalcite. A basic carbonate of zinc and copper [$2(Zn,Cu)CO_3 . 3(Zn,Cu)(OH)_2$]. An unusual mineral. Socorro County, Magdalena district.

Azurite. Basic copper carbonate [$2CuCO_3 . Cu(OH)_2$]. Occurs in most districts in which copper minerals are present. Generally in very small amounts, except in deposits in "Red Beds" in which it is one of the principal minerals. Catron County, Mogollon district, with silver ores. Dona Ana County, Hembrillo district. Eddy County (?). Grant County: Burro Mountains and Central districts; Pinos Altos district with lead-silver-zinc ores; Santa Rita district. Guadalupe County, Pastura district, important. Hidalgo County: Apache No. 2 and Fremont districts; Hachita district, with lead-silver ores; Lordsburg and San Simon districts. Lincoln County: Estey district, important; Jicarilla district, with gold ores. Mora County, Coyote district. Otero County, Tularosa and Sacramento districts, important. Rio Arriba County, Abiquiu, Bromide and Gallina districts. Sandoval County: Nacimiento district, important; Placitas district. San Miguel County: Rociada district; Tecolote district, important. Santa Fe County: Glorieta district, important; La Bajada district. Sierra County, Caballos Mountains, Hillsboro and Chloride districts. Socorro County: Hansonburg district, with lead ores; Magdalena, Salinas Peak, Mockingbird Gap, Water Canyon, and Ladrones Mountains districts; Chupadero, Rayo and Scholle districts, important. Valencia County, Zuni Mountains district.

Bornite (peacock ore, purple copper ore). Copper-iron sulphide (Cu_5FeS_4). Catron County, Mogollon district, with silver ores. Grant County, Santa Rita district. Hidalgo County, Lordsburg and San Simon districts. Guadalupe County, Pastura district. Lincoln County, Estey district. Otero County, Sacramento district. Rio Arriba County, Gallina district. Sandoval County, Nacimiento district. San Miguel County, Rociada, Tecolote and Willow Creek districts. Sierra County: Caballos Mountains and Chloride districts; Hermosa and Hillsboro districts, with silver ores. Socorro County: Goodfortune Creek and Joyita Hills, rare; Magdalena (?) and Scholle districts. Taos County, Twining district.

Bournonite (wheel ore, cog wheel ore). Copper-lead sulphantimonite [$3(Pb,Cu_2)S . Sb_2S_3$]. Grant County, Central district. Santa Fe County, Cerrillos district.

Brochantite. A basic sulphate of copper [$CuSO_4 . 3Cu(OH)_2$]. Dona Ana County, Organ district. Socorro County, Magdalena district (?).

Chalcanthite (blue vitriol). Hydrous copper sulphate ($CuSO_4 . 5H_2O$). San Miguel County, Willow Creek district. Socorro County, Magdalena district.

Chalcocite (copper glance). Copper sulphide (Cu_2S). Catron County, Mogollon district, with silver ores. Dona Ana County: Hembrillo district, principal ore mineral; Organ District. Eddy County (?). Grant County: Burro Mountains district, principal ore mineral; Hanover-Fierro district, with iron and zinc ores; Santa Rita district, very important. Guadalupe County, Pastura district. Hidalgo County, Apache No. 2 and Hachita districts. Lincoln County: Estey district; Jicarilla district, with gold ores. Mora County, Coyote district. Otero County: Orogrande district; Tularosa and Sacramento districts, important. Rio Arriba County, Abiquiu district (?). Sandoval County, Nacimiento district, principal ore mineral. San Miguel County: Rociada and Willow Creek districts; Tecolote district, important. Santa Fe County, Glorieta and La Bajada districts. Sierra County, Caballos Mountains, Hillsboro and Chloride districts. Socorro County: Goodfortune Creek, principal ore mineral; Hansonburg district; Jones Camp, with iron ore; Joyita Hills and Ladrones Mountains, small; Magdalena, Mill Canyon, Mockingbird Gap and North Magdalena districts; Rayo district, chief ore mineral; Scholle district, important; Water Canyon district, rare. Taos County, Picuris district. Valencia County, Zuni Mountains.

Chalcopyrite (copper pyrites, yellow copper ore). Copper-iron sulphide ($CuFeS_2$). Catron County, Mogollon district, with silver ores. Colfax County, Cimarroncito, Elizabethtown, and Baldy districts, with gold ores. Dona Ana County: Gold Camp, in gold veins; Organ district, with copper deposits only. Grant County: Burro Mountains and Central districts; Fierro-Hanover district, with iron ores; Hachita district, rare; Pinos Altos and Santa Rita districts; Steeplerock district, in gold-silver veins; White Signal district, in gold veins. Hidalgo County: Apache No. 2, Fremont, Hachita, Lordsburg and San Simon districts; Steins Pass district, with silver ores. Lincoln County: Estey district, in "Red Beds"; Nogal district, with gold ores. Luna County, Florida Mountains district. Otero County: Orogrande district, with gold-bearing contact metamorphic ores; Sacramento and Tularosa districts. Rio Arriba County, Bromide and Hopewell districts. Sandoval County, Cochiti district, rare. San Miguel County: El Porvenir district, with tungsten and molybdenum minerals; Rociada, Tecolote, and Willow Creek districts. Santa Fe County, Cerrillos, Santa Fe, New Placers and Old Placers districts. Sierra County, Caballos Mountains, Chloride, Hermosa, Hillsboro, Kingston and Tierra Blanca districts, chiefly with silver ores. Socorro County: Goodfortune Creek; Grandview Canyon, with bismuth ore; Hansonburg district; Joyita Hills and Lemitar Mountains, very small; Magdalena and North Magdalena districts; Salinas Peak district; Scholle district, in "Red Beds"; Water Canyon district. Taos County, Picuris, Red River and Twining districts. Valencia County, Zuni Mountains.

Chalcotrichite. A variety of cuprite.

Chalmersite. Magnetic copper-iron sulphide ($Cu_2S . Fe_4S_5$). Grant County, Fierro-Hanover district, with contact-metamorphic iron ores.

Chrysocolla. Impure hydrated copper silicate ($CuSiO_3 . 2H_2O$). Catron County, Mogollon district with silver ores. Colfax County, Elizabethtown district, with gold ores. Dona Ana County, Organ district. Grant County, Burro Mountains and Santa Rita districts. Hidalgo County, Apache No. 2, Lordsburg and San Simon districts. Lincoln County, Jicarilla district, with gold ores. Otero County, Orogrande district. Sandoval County, Nacimiento district. San Miguel County, Willow Creek district. Santa Fe County, Santa Fe Mountains. Socorro County: Joyita Hills, rare; Magdalena district, rare, and North Magdalena district, common; Ladrones Mountains, Mill Canyon, Mockingbird Gap, Ojo Caliente, San Lorenzo and Sulphur Canyon districts. Taos County, Picuris district.

Copper (native). An element (Cu). Grant County: Burro Mountains and Pinos Altos districts, rare; Santa Rita district, important; Central district. Rio Arriba County, Bromide district, rare. Sierra County, Hillsboro district. Socorro County, Magdalena, Mockingbird Gap, San Lorenzo and Water Canyon districts, rare. Valencia County, Zuñi Mountains, rare.

Copper arsenates. See under arsenic minerals.

Copper-pitch ore. This is a secondary material of complex character and uncertain composition.[1] It may contain oxides of copper, zinc and manganese, with considerable water and silica. Catron County, Mogollon district, with silver ores. Hidalgo County, Fremont district. Otero County, Orogrande district. Socorro County, Magdalena district (?).

Covellite (indigo copper). Copper sulphide (CuS). Occurs as traces or very small quantities in all its occurrences except one, as noted below. Grant County, Central district. Rio Arriba County, Bromide district. Socorro County: Goodfortune Creek, Hansonburg, Joyita Hills, Ladrones Mountains, Magdalena, North Magdalena, Scholle and Water Canyon districts; important in Mill Canyon district.

Probably occurs in all copper deposits, at least in microscopic amounts, but has been reported only from above districts.

Cuprite (red copper). Copper oxide (Cu_2O). Catron County, Mogollon district, rare. Colfax County, Elizabethtown district, with gold ores. Grant County, Burro Mountains and Santa Rita districts. Lincoln County, Jicarilla district, with cupriferous gold ores. Rio Arriba County, Bromide district. San Miguel County, Rociada district. Sierra County: Caballos Mountains district; Hillsboro district, chalcotrichite. Socorro County: Magdalena, Mockingbird Gap, San Lorenzo and Water Canyon districts; important in Mill Canyon district. Taos County, Picuris district.

Cuprodescloizite. See under vanadium minerals.

Dioptase. Hydrated copper silicate (H_2CuSiO_4). Grant County, Santa Rita district.

Domeykite. Copper arsenide (Cu_3As). Grant County, Pinos Altos (?) and Central (?) districts.

Enargite. Sulpharsenate of copper (Cu_3AsS_4). Grant County, Central (?) and Pinos Altos (?) districts. Socorro County, Hansonburg district (?), trace.

Gerhardtite. Basic copper nitrate [$Cu(NO_3)_2 . 3Cu(OH)_2$]. Socorro County, Magdalena district (?).

Libethenite. Basic copper phosphate [$Cu_3P_2O_8 . Cu(OH)_2$]. Grant County, Santa Rita district.

Malachite. Basic copper carbonate [$CuCO_3 . Cu(OH)_2$]. Occurs in practically all districts where copper minerals are present and is an important ore mineral in deposits in sandstone. Catron County, Mogollon district. Colfax County, Cimarroncito, Elizabethtown and Baldy districts. Dona Ana County, Hembrillo and Organ districts. Grant County, Burro Mountains, Central, Fierro, Pinos Altos and Santa Rita districts. Guadalupe County, Pastura district, important. Hidalgo County, Apache No. 2, Fremont, Hachita, Lordsburg and San Simon districts. Lincoln County, Estey and Jicarilla districts. Luna County, Florida Mountains. Mora County, Coyote district. Otero County: Orogrande district; Tularosa and Sacramento districts, important. Rio Arriba County, Abiquiu, Bromide and Gallina districts. Sandoval County, Nacimiento and Placitas districts. San Miguel County: El Porvenir district, with tungsten and molybdenum minerals; Rociada district; Tecolote district, important; Willow Creek district. Santa Fe County, Glorieta and La Bajada districts. Sierra County, Caballos Mountains, Hillsboro and Chloride districts. Socorro County: Chupadero, Goodfortune Creek, Grandview Canyon, Hansonburg, Jones Camp, Joyita Hills, Ladrones

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[1] Emmons, W. H., Enrichment of ore deposits: U. S. Geol. Survey Bull. 625, pp. 185-186, 1917.

Mountains, Magdalena, Mill Canyon, Mockingbird Gap, North Magdalena, Ojo Caliente, San Lorenzo, Salinas Peak, Socorro Peak, Sulphur Canyon and Water Canyon districts; San Jose district, rare in gold-silver veins; Rayo and Scholle districts, in sandstone copper deposits. Taos County, Picuris district. Valencia County, Zuñi Mountains.

Melaconite. A variety of tenorite.

Melanochalcite. Copper oxide similar to melaconite. Grant County, Burro Mountains district (?).

Pearceite. See under silver minerals.

Rickardite. See under tellurium minerals.

Tennantite (gray copper). Sulpharsenite of copper ($Cu_8As_2S_7$). Hidalgo County, San Simon district (?). Socorro County, Hansonburg district, most important copper mineral.

Tenorite. Copper oxide (CuO). Not a common mineral. Grant County: Burro Mountains district, melaconite (?); Santa Rita district, melaconite. Hidalgo County, Fremont district (?). Socorro County, Magdalena and San Lorenzo districts.

Tetrahedrite (gray copper, fahlerz). Sulphantimonite of copper ($Cu_8Sb_2S_7$). Catron County, Mogollon district, with silver ores. Dona Ana County, Organ district, in silver-lead veins. Hidalgo County, Pyramid (reported) and San Simon (?) districts. Rio Arriba County, Bromide district. San Miguel County, Willow Creek district. Taos County, Picuris district (?).

GOLD

Gold (native). An element (Au).

Gold occurs in lode deposits as follows:

Catron County, Mogollon district, rare. Colfax County, Elizabethtown and Baldy districts. Dona Ana County, Gold Camp. Grant County, Steeplerock district. Hidalgo County, Sylvanite and Steins Pass districts. Lincoln County, Jicarilla, Nogal and White Oaks districts. Otero County, Orogrande district. Rio Arriba County, Bromide and Hopewell districts. Sandoval County, Cochiti district. Santa Fe County, New Placers and Old Placers districts. Sierra County, Chloride, Tierra Blanca and Hillsboro districts. Socorro County: Magdalena, Mill Canyon and Water Canyon districts, rare; Rosedale and San Jose districts. Taos County, Anchor, Red River and Twining (?) districts.

Gold occurs also as a constituent of base metal ores in most districts; it constitutes a very important part of the value of some ores. The districts in which gold occurs in auriferous sulphides in appreciable proportions, in addition to those listed above, are as follows:

Bernalillo County, Tijeras district. Catron County, Mogollon district. Colfax County, Cimarroncito district. Dona Ana County, Organ and Texas districts. Grant County, Burro Mountains, Central, Gold Hill, Malone, Pinos Altos, Santa Rita and White Signal districts. Hidalgo County, Apache No. 2, Fremont, Lordsburg and Red Hill districts. Lincoln County, Gallinas Mountains district. Luna County, Tres Hermanas and Victorio districts. Otero County, Tularosa district. Sandoval County, Jemez and Placitas districts. San Miguel County, Rociada and Willow Creek districts. Santa Fe County, Santa Fe district. Sierra County, Tierra Blanca district. Socorro County, Cat Mountain, Magdalena, Mill Canyon, North Magdalena, San Mateo Mountains and Socorro Peak districts. Taos County, Picuris and Rio Hondo districts.

Gold is also reported[1] in the Guadalupe Mountains in Chaves, Eddy and Otero Counties.

Gold in placer deposits occurs as follows:

[1] Schrader, F. C., Stone, R. W., and Sanford, Samuel, Useful minerals of the United States: U. S. Geol. Survey Bull. 624, p. 212, 1917.

Bernalillo County, Coyote Canyon district. Chaves County, on the Rio Hondo. Colfax County, Cimarroncito, Elizabethtown and Poñil districts. Grant County, Malone, Gold Camp and Pinos Altos districts. Hidalgo County, Lordsburg and Sylvanite districts. Lincoln County, Gallinas, Jicarilla, Nogal and White Oaks districts, and along the Rio Hondo. Otero County, Orogrande district, dry placers. Rio Arriba County, Abiquiu and Hopewell districts. Sandoval County, Placitas district. San Miguel County, Willow Creek district. Santa Fe County, New Placers, Old Placers and Santa Fe districts. Sierra County, Hillsboro and Pittsburg districts, and Caballos Mountains opposite Derry. Taos County, Rio Hondo and Red River districts, and at a number of places along the Rio Grande.

Petzite. Silver-gold telluride [$(Ag, Au)_2Te$]. A telluride, believed to be petzite, occurs in the Red River district, Taos County.

IRON

Arsenopyrite. See under arsenic minerals.

Columbite. See under tantalum minerals.

Hematite. Iron oxide (Fe_2O_3). Common in oxidized ore throughout the state. The distribution of specularite, the crystalline variety, is listed separately. Mined at Boston Hill, Grant County, with manganese and other iron oxides. Occurs in the following districts, possibly in commercial quantities:

Colfax County, Elizabethtown district, prospected at Iron Mountain. Santa Fe County, formerly mined in Glorieta district. Socorro County, Iron Mountain district (?).

Jarosite. Basic potassium-iron sulphate [$K_2Fe_6(OH)_{12}(SO_4)_4$]. Grant County, Central district. Socorro County: Goodfortune Creek and Grandview Canyon districts, common; Magdalena district. Undoubtedly occurs in other districts also, but has probably been included in reports under the term "limonite."

Limonite (brown hematite). Includes all the hydrated iron oxides. Limonite is a common oxidation product of iron-bearing minerals and therefore generally occurs in the oxidized zone of all lode deposits. Workable bodies of limonite occur in the Zuñi Mountains, Valencia County.

Magnetite (magnetic iron ore). Iron oxide (Fe_3O_4). Is the principal mineral of New Mexico's iron ores. Occurs most commonly in contact-metamorphic deposits. Colfax County, Cimarroncito and Elizabethtown districts, in auriferous contact-metamorphic ores. Grant County: Big Burro Mountains; Chloride Flat district, with silver ores; Fierro district, important; Santa Rita district. Lincoln County, Capitan Mountain (?), Gallinas Mountain, Jicarilla (?) and White Oaks (?) districts, in iron-ore deposits. Otero County, has been mined in Orogrande district. Rio Arriba County, Bromide district; forms an iron-ore deposit in Hopewell district. Santa Fe County, Old Placers district, in gold-quartz veins. Sierra County, Chloride district, possible iron ore deposit. Socorro County: principal mineral at Jones Camp and elsewhere on the Chupadera Mesa; Magdalena district, with lead-zinc deposits.

Melanterite (copperas). Hydrous iron sulphate ($FeSO_4 . 7H_2O$). Socorro County, Magdalena district, uncommon.

Plumbojarosite. See under lead minerals.

Pyrite (iron pyrites, fool's gold). Iron sulphide (FeS_2). Pyrite is the most common metallic constituent of lode deposits in some of which it is auriferous. Catron County, Mogollon district. Colfax County, Cimarroncito, Elizabethtown and Baldy districts. Dona Ana County, Gold Camp, Modoc, Organ and Texas districts. Grant County, Fleming, Burro Mountains, Carpenter, Central, Fierro-Hanover, Gold Hill, Pinos Altos, Santa Rita, Steeplerock and White Signal districts. Hidalgo County, Apache No. 2, Hachita, Lordsburg, Steins Pass and San Simon districts. Lincoln County: Estey district, with copper in "Red Beds"; Jicarilla, Nogal and White Oaks districts. Luna County, Cooks Peak, Tres Hermanas and Victorio districts. Otero County, Orogrande district; Tularosa district, with copper in "Red Beds." Rio Arriba County, Bromide and Hopewell districts. Sandoval County, Cochiti district. San Miguel County: Rociada and Willow Creek districts; Tecolote district, with copper in "Red Beds." Santa Fe County, New Placers (rare) and Old Placers districts. Sierra County, Chloride, Hermosa, Hillsboro and Kingston districts. Socorro County: Goodfortune Creek, Grandview Canyon, Ladrones Mountains, Magdalena, Mill Canyon, Rosedale (?) San Jose and Water Canyon districts; Scholle district, with copper in "Red Beds." Taos County, Anchor, Picuris, Red River, and Twining districts. Valencia County, Zuñi Mountains.

Pyrrhotite (magnetic pyrites). Iron sulphide (Fe_7S_8). Colfax County, Elizabethtown district, locally with pyrite and other minerals in cupriferous gold deposits. Grant County, Santa Rita district. Santa Fe County: Santa Fe district, with copper ore in amphybolite; New Placers district, rare with chalcopyrite in contact-metamorphic ores. San Miguel County, Willow Creek district. Socorro County, Magdalena district (?) rare.

Specularite (specular iron, micaceous hematite). A crystalline variety of hematite, iron oxide (Fe_2O_3). Specularite is always a primary mineral and is common in contact-metamorphic deposits, generally associated with magnetite. Catron County: Mogollon district, occasionally in copper-bearing veins; Taylor Creek district, with cassiterite. Colfax County, Cimarroncito and Elizabethtown districts. Dona Ana County, Organ district. Grant County, Burro Mountains and Central districts; Fierro-Hanover district, with magnetite in iron ore; Pinos Altos district, with copper and gold ores; Santa Rita, sparingly with copper ores; Steeplerock district, with auriferous pyrite. Hidalgo County, Lordsburg district in copper-tourmaline veins. Luna County, Tres Hermanas district. Otero County, Orogrande district, important in iron ore. Rio Arriba County, Bromide and Hopewell districts, locally. Santa Fe County: New Placers district; Old Placers district, with gold-quartz veins. Sierra County: Chloride district, with magnetite; Lake Valley district, in gold-quartz veins, rare. Socorro County: Ladrones Mountains district; Magdalena district, abundant in contact zone. Taos County, Red River district.

LEAD

Altaite. See under tellurium minerals.

Anglesite. Lead sulphate ($PbSO_4$). Anglesite is common in deposits which contain galena, from which it is derived. Dona Ana County, Organ district. Grant County, Central district. Luna County, Cooks Peak and Victorio (?) districts. Sierra County, Caballos Mountains district. San Miguel County, Willow Creek district. Socorro County, Hansonburg, Joyita Hills, Magdalena, Mockingbird Gap and Water Canyon districts. Anglesite undoubtedly occurs in most other districts in which galena is present, but probably as an inconspicuous coating.

Bournonite. See under copper minerals.

Cerusite (white lead ore). Lead carbonate ($PbCO_3$). Cerusite is most common in lead deposits in limestones. Dona Ana County, Organ district. Grant County, Central, Georgetown, Gold Hill, and Hanover districts. Hidalgo County: Fremont, Hachita and Lordsburg districts; San Simon district, principal ore mineral. Luna County: Cooks Peak district, principal ore mineral; Florida Mountains, Fremont and Victorio (?) districts. San Miguel County, Willow Creek district. Santa Fe County, New Placers district, with manganese ore. Sierra County: Caballos Mountains and Chloride districts; Hillsboro district, important; Lake Valley district, very rich in silver. Socorro County: Hansonburg district; Magdalena district, very important; Mockingbird Gap, North Magdalena, Ojo Caliente and Water Canyon districts.

Descloizite. See under vanadium minerals.

Galena (lead glance). Lead sulphide (PbS). Much galena is argentiferous, and many deposits are made economically workable by the silver content. Bernalillo County, Tijeras Canyon district. Catron County, Mogollon district, with silver and copper ores. Colfax County, Elizabethtown and Baldy (?) districts, small. Dona Ana County, Modoc and Organ districts. Grant County: Burro Mountains district, a little with gold ores; Carpenter and Central districts, principal ore mineral; Chloride Flat district, unimportant, with silver ores; Fierro-Hanover district, subordinate with iron and zinc ores; Gold Hill district, sparingly, with gold and silver ores; Pinos Altos, Santa Rita, Steeplerock and White Signal districts. Hidalgo County, Fremont, Hachita, Lordsburg, Steins Pass and San Simon districts. Lincoln County, Nogal district. Luna County: Cooks Peak, Florida Mountains and Tres Hermanas districts; Victorio district, principal ore mineral. Otero County, Sacramento district, in "Red Beds." Rio Arriba County: Bromide district, locally; Hopewell district, sparingly. Sandoval County: Cochiti district, rare; Placitas district, principal ore mineral. San Miguel County, Rociada and Willow Creek districts. Santa Fe County: Cerrillos district, prominent; Santa Fe district; New Placers district, formerly important; Old Placers district (?). Sierra County: Caballos Mountains and Chloride districts, unimportant; Hermosa and Kingston districts, principal ore mineral; Hillsboro district, with cerusite; Lake Valley, small, very rich in silver; Tierra Blanca district. Socorro County: Chupadero district, in "Red Beds"; Goodfortune Creek district, small; Hansonburg, Joyita Hills, Lemitar Mountains, Magdalena, Mill Canyon, Mockingbird Gap, North Magdalena, Salinas Peak, Socorro Peak and Water Canyon districts. Taos County, Red River district. Valencia County, Zuñi Mountains.

Massicot. Lead monoxide (PbO). Grant County, Chloride Flat district (?).

Melanotekite. Lead-iron silicate ($3PbO \cdot 2Fe_2O_3 \cdot 3SiO_2$). Rare. Sierra County, Hillsboro district (?).

Mimetite. Lead chlorarsenate [$Pb_4(PbCl)(AsO_4)_3$]. Socorro County, Socorro Peak district.

Minium (red lead). Lead oxide (Pb_3O_4). An uncommon mineral. Sierra County, Hillsboro district, on the Stuck claims.

Plumbojarosite. Basic lead-iron sulphate [$PbFe_6(OH)_{12}(SO_4)_4$]. Grant County, Central district. Luna County, Cooks Peak district. Socorro County, Magdalena and Water Canyon districts. Plumbojarosite is more common than at one time supposed and probably occurs in other districts.

Pyromorphite (green lead ore). Lead chlorophosphate [$(PbCl)Pb_4(PO_4)_3$]. Grant County, Central district. Sierra County, Caballos district, reported.

Vanadinite. See under vanadium minerals

Wulfenite. See under molybdenum minerals.

MANGANESE

The primary ore of many deposits includes an appreciable amount of manganese. On oxidation the manganese is converted to the different oxides and is concentrated in this form by residual enrichment. Many of the manganese deposits of New Mexico have been so formed.

Alabandite. Manganese sulphide (MnS). An uncommon mineral. Santa Fe County, New Placers district. Sierra County, Kingston district, fairly common.

Ankerite. A carbonate of calcium, magnesium, iron and variable proportions of manganese [$CaCO_3 \cdot (Mg, Fe, Mn)CO_3$]. Common in the Silver City manganese district, Grant County, and probably occurs in the primary ore of other manganese deposits.

Chalcophanite. See under zinc minerals.

Columbite. See under tantalum minerals.

Mallardite. Hydrous manganese sulphate ($MnSO_4 . 7H_2O$). Sierra County, Lake Valley district (?)

Manganite (gray manganese ore). Hydrous manganese oxide ($Mn_2O_3 . H_2O$). Dona Ana County, Rincon district (?). Grant County, Fierro manganese and Silver City manganese districts. Luna County, Little Florida Mountains. Sierra County, Lake Valley district, mined with silver ore and independently as manganese ore.

Manganiferous calcite. Black calcite containing manganese oxide occurs in many manganese deposits. The districts in which this material is prominent are:

Luna County, Little Florida Mountains. Sierra County, Derry district. Socorro County, Luis Lopez and Magdalena Mountains manganese districts.

Psilomelane. Manganese hydrate, probably H_4MnO_5. Dona Ana County, Rincon district. Grant County, Cap Rock Mountain district. Luna County, Cooks Range manganese district, Florida Mountains and Little Florida Mountains. Santa Fe County, Santa Fe manganese district. Sierra County: Hot Springs district; Lake Valley district, mined for silver and independently as an ore of manganese. Socorro County: Luis Lopez district; Magdalena district, with oxidized lead-zinc ores; Magdalena Mountains manganese district; San Lorenzo and Socorro manganese districts.

Pyrolusite. Manganese dioxide (MnO_2). Very common in oxidized zones, generally associated with limonite. Catron County, Mogollon district. Grant County: Burro Mountains, Chloride Flat and Fierro districts; Silver City manganese district. Hidalgo County, Fremont, Lordsburg and San Simon districts. Lincoln County, White Oaks district. Luna County, Little Florida Mountains manganese district. Santa Fe County: Santa Fe manganese district; New Placers district, with lead and manganese ores. Sierra County: Derry manganese district; Hillsboro district, with lead and manganese ores; Kingston district, with silver-lead, copper and manganese ores; Lake Valley district, with silver and manganese ores. Socorro County: Magdalena district, with oxidized lead-zinc ores; Magdalena Mountains manganese district; Mill Canyon district, with manganiferous calcite; Mockingbird Gap and Water Canyon districts; San Lorenzo and Socorro manganese districts.

Rhodochrosite. Manganese carbonate ($MnCO_3$). Sierra County, Kingston district.

Wad. Wad is a mixture of manganese oxides. Grant County, Fierro and Silver City manganese districts. Luna County, Little Florida Mountains. Sierra County: Derry district; Hillsboro district, with oxidized lead and manganese ores; Hot Springs district; Kingston and Lake Valley districts, with oxidized ores. Socorro County: Magdalena district, with oxidized lead-zinc ores; Magdalena Mountains manganese district; Ojo Caliente district, with oxidized lead ore; San Lorenzo manganese district.

MOLYBDENUM

Molybdenite. Molybdenum sulphide (MoS_2). Colfax County, Baldy district. Dona Ana County, Organ and Texas districts, reported. Grant County: Burro Mountains, reported; Fierro-Hanover district, occasionally with iron ore; Santa Rita district, small quantities with copper ore. Hidalgo County, Lordsburg district, sparingly. Rio Arriba County, Bromide district, locally. San Miguel County: El Porvenir district, with copper and tungsten minerals, mined; Rociada district, reported. Santa Fe County, Santa Fe and Old Placers (?) districts. Taos County: Red River district, important deposit; Twining district.

Molybdite (molybdic ocher). Hydrous ferric molybdate ($Fe_2O_3 . 3MoO_3 . 7H_2O$). Erroneously given in textbooks on mineralogy as the oxide, (MoO_3).

San Miguel County, El Porvenir district, with molybdenite. Taos County, in the oxidized zone of the Red River district molybdenum deposit.

Wulfenite. Lead molybdate ($PbMoO_4$). Common in some oxidized lead ores. Dona Ana County, Organ district, has been mined as molybdenum ore. Grant County, Central district. Hidalgo County, Lordsburg district. Luna County, Victorio district. Santa Fe County, Los Cerrillos district, reported. Sierra County: Caballos Mountains, reported; Hillsboro district, prominent.

NICKEL

Annabergite. Hydrous nickel arsenate ($Ni_3As_2O_8 . 8H_2O$). Grant County, Black Hawk district.

Chloanthite-smaltite. Chloanthite is essentially nickel diarsenide ($NiAs_2$). Smaltite is essentially cobalt diarsenide ($CoAs_2$). Each usually contains some of the other. Grant County, Black Hawk district, with native silver and other silver minerals.

Niccolite (copper nickel). Nickel arsenide (NiAs). Occurrence same as chloanthite-smaltite.

Nickel-skutterudite. Nickel-cobalt-iron arsenide $[(Ni, Co, Fe)As_3]$. Grant County, Black Hawk district, type locality.

SILVER

Although silver is present in the form of recognizable silver minerals in certain types of deposits, most of the silver production of the State comes from base-metal deposits which carry the silver combined with certain of the base-metal sulphides.

Argentite (silver glance). Silver sulphide (Ag_2S). Argentite is usually a product of secondary enrichment. Catron County, Mogollon district. Dona Ana County, Organ district, rare. Grant County: Fleming, Black Hawk, Chloride Flat (?), Georgetown, Lone Mountain, Pinos Altos, Steeplerock and Telegraph districts. Hidalgo County, Lordsburg (?) and Steins Pass districts. Luna County, Florida Mountains district. Sandoval County, Cochiti district. San Miguel County, Willow Creek district. Sierra County: Chloride, Hermosa, Kingston, Lake Valley (rare) and Tierra Blanca districts. Socorro County, North Magdalena and Socorro Peak districts. Taos County, Picuris district, reported.

Bromyrite. Silver bromide (AgBr). Grant County, Georgetown district. Rio Arriba County, Bromide distirct (?). Sierra County, Tierra Blanca district, not common.

Cerargyrite (horn silver). Silver chloride (AgCl). Catron County, Mogollon district. Dona Ana County, Organ district, rare. Grant County, Burro Mountains, Fleming, Black Hawk, Chloride Flat, Georgetown, Lone Mountain and Pinos Altos districts. Hidalgo County, Apache No. 2, Fremont, Hachita, Lordsburg and Steins Pass districts. Luna County, Florida Mountains. Rio Arriba County, Bromide district. Sierra County: Chloride, Hermosa and Hillsboro districts; Kingston district, locally; Lake Valley district, chief silver mineral, in large bodies; Tierra Blanca district, not common. Socorro County, San Jose and Socorro Peak districts. Taos County, Picuris district.

Embolite. Silver chloro-bromide [Ag(Br, Cl)]. Sierra County, Lake Valley district. Socorro County, Socorro Peak district (?).

Hessite. Silver telluride (Ag_2Te). Sierra County, Tierra Blanca district, principal mineral at the Lookout mine.

Iodyrite. Silver iodide (AgI). Grant County, Georgetown district, reported. Sierra County, Lake Valley district.

Pearceite. Sulpharsenite of silver ($9Ag_2S . As_2S_3$). Socorro County, Magdalena district.

Petzite. See under gold minerals.

Polybasite. Sulphantimonite of silver ($9Ag_2S . Sb_2S_3$). Grant County, Telegraph district (?).

Proustite (light ruby silver). Sulpharsenite of silver ($3Ag_2S . As_2S_3$). Grant County, Georgetown district. Sierra County, Kingston and Lake Valley districts. San Miguel County, Willow Creek district.

Pyrargyrite (dark ruby silver). Sulphantimonite of silver ($3Ag_2S . Sb_2 S_3$). Catron County, Mogollon district, rare. Grant County, Black Hawk, Georgetown and Gold Hill districts. Sierra County, Kingston district.

Silver (native). An element (Ag). Native silver is usually the result of secondary enrichment. Catron County, Mogollon district, rare. Grant County, Black Hawk, Chloride Flat, Fleming, Georgetown, Gold Hill, Lone Mountain and Pinos Altos districts. Hidalgo County, Lordsburg and San Simon districts. Luna County, Victorio district. Sierra County, Chloride, Hermosa, Hillsboro, Kingston, Lake Valley (rare) and Tierra Blanca districts. Socorro County, Cat Mountain (reported), Magdalena, North Magdalena (reported), San Jose and Socorro Peak districts. Valencia County, Copperton district.

Stephanite (brittle silver ore). Sulphantimonite of silver ($5Ag_2S . Sb_2 S_3$). Hidalgo County, Fremont district (?). Rio Arriba County, Bromide district. Sierra County, Lake Valley district. Socorro County, San Jose district (?)

Stromeyerite. Silver-copper sulphide [$(Ag, Cu)_2S$]. Catron County, Mogollon district, important ore mineral.

Xanthoconite (rittingerite). Silver sulpharsenate ($3Ag_2S . As_2S_5$). Santa Fe County, Los Cerrillos district.

TANTALUM

Columbite-tantalite. Niobate and tantalate of iron and manganese [$(Fe, Mn) (Nb, Ta)_2O_6$]. Rio Arriba County, Petaca district, mined.

TELLURIUM

Tellurium occurs in New Mexico chiefly in combination with some other more valuable element.

Altaite. Lead telluride (PbTe). Reported from Organ Mountains, Dona Ana County.

Hessite. See under silver minerals.

Petzite. See under gold minerals.

Rickardite. Copper telluride (Cu_4Te_3). Reported from Organ Mountains, Dona Ana County.

Tellurium (native). An element (Te). Catron County, Mogollon district. Reported from Burro Mountains, Grant County, and said to be gold-bearing.

Tetradymite. See under bismuth minerals.

TIN

Cassiterite (tin-stone, tin ore, stream tin). Tin oxide (SnO_2). Catron and Sierra counties, Taylor Creek district, in lode and placer deposits. Sierra County, Chloride district, in extrusive porphyries and as stream tin.

TUNGSTEN

Cuprotungstite. Hydrous copper tungstate ($CuWO_4 . 2H_2O$). Rio Arriba County, Rinconada district (?), with wolframite.

Ferberite. Iron tungstate ($FeWO_4$). Colfax County, Elizabethtown district. San Miguel County, El Porvenir district, with scheelite, and bismuth, molybdenum and copper minerals.

Hübnerite. Manganese tungstate ($MnWO_4$). Hidalgo County, Hachita district (?). Lincoln County: Nogal (Parsons) district; White Oaks district, mined with gold ore and as a tungsten ore. Luna County, Victorio district, with wolframite.

Scheelite. Calcium tungstate ($CaWO_4$). Hidalgo County: Apache No. 2 district, in contact-metamorphic ore, in considerable quantities at one place; Fremont district (?), at the Daisy Mine. Luna County, Victorio district (?) with wolframite. San Miguel County, El Porvenir district. Socorro County, Grandview Canyon, San Andres Mountains, with bismuth ore.

Wolframite. Iron manganese tungstate [$(Fe, Mn)WO_4$]. Hidalgo County, Hachita district, reported with argentiferous galena and other sulphides. Lincoln County, White Oaks district. Luna County, Victorio district, small quantity mined. Rio Arriba County, Rinconada district. Taos County, Picuris district.

Production of tungsten ore has been reported[1] from the Orogrande district, but the mineralogy of the occurrence is not known.

URANIUM

Autunite (lime uranite). Hydrous calcium-uranium phosphate [$Ca(UO_2)_2P_2O_8 . 8H_2O$]. Grant County, White Signal district, with torbernite. Socorro County, San Lorenzo district (?).

Carnotite. Hydrous potassium-uranium vanadate ($K_2O . 2U_2O_3 . V_2O_5 . 3H_2O$). With vanadium minerals at Carrizo Mountain, Catron County. Socorro County, Scholle district. Oxides of uranium and vanadium have been reported from one place in the Cochiti district, Sandoval County, but the mineralogy of the occurrence is not known. It is probably carnotite.

Gummite. [$(Pb, Ca, Ba)O . 3UO_3 . SiO_2 . 5H_2O$]. An alteration product of uraninite. Rio Arriba County, Petaca district, in pegmatite with other radio-active minerals.

Samarskite. A columbate and tantalate of iron, calcium, uranium, cerium, yttrium, etc. Rio Arriba County, Petaca district, in pegmatite.

Torbernite (copper uranite). Hydrous copper-uranium phosphate [$Cu(UO_2)_2P_2O_8 . 12H_2O$]. Grant County, White Signal district, with autunite. Socorro County, San Lorenzo district (?).

Uraninite (pitchblende). A complex uranium mineral containing also rare earths, radium, lead, helium, nitrogen and other elements. Rio Arriba County, Petaca district, in pegmatite with samarskite and other uranium minerals.

Uranophane. Hydrous calcium-uranium silicate ($CaO . 2UO_3 . 2SiO_2 . 6H_2O$). Rio Arriba County, Petaca district, with other uranium minerals in pegmatite. Socorro County, San Lorenzo district (?).

VANADIUM

Vanadium minerals are common in New Mexico in certain oxidized lead deposits.

Copper vanadate. Torrance County, Scholle district, with copper ores in "Red Beds," mineralogic character unknown.

Cuprodescloizite (psittacinite). A basic vanadate of lead, zinc and copper [$2PbO . 2(Cu, Zn)O . V_2O_5 . H_2O$]. Grant County, Central district near Vanadium, with vanadinite. Otero County, Sacramento district, with galena ores in "Red Beds." Sierra County, Caballos Mountains, in lead-vanadium ores. Socorro County, Hansonburg district.

Descloizite. Basic lead-zinc vanadate [$4(Pb, Zn)O . V_2O_5 . H_2O$]. Grant County, Georgetown district. Sierra County, Lake Valley district. Socorro County, North Magdalena district.

[1] Finlay, J. R., Report of appraisal of mining properties of New Mexico: N. Mex. State Tax Com., p. 82, 1922.

Endlichite. A variety of vanadinite containing considerable arsenic. Grant County, Central district. Sierra County, Lake Valley and Hillsboro districts.

Vanadinite. Lead chlorovanadate ($9PbO . 3V_2O_5 . PbCl_2$). The most common vanadium mineral in New Mexico. Dona Ana County: Black Mountain district, associated with galena and barite; Memphis mine, Organ Mountains. Grant County: Georgetown district, with silver ores; at Vanadium, near Santa Rita. Sierra County, Caballos Mountains, Hillsboro and Lake Valley districts. Socorro County, North Magdalena district, in lead veins in volcanic rocks.

ZINC

Aurichalcite. Basic zinc-copper carbonate [$2(Zn,Cu)CO_3 . 3(Zn,Cu)(OH)_2$]. Socorro County, Magdalena district.

Calamine. Hydrous zinc silicate (H_2ZnSiO_5). Grant County: Fierro-Hanover district, important; Central and Pinos Altos districts. Luna County, Tres Hermanas district, important. Socorro County: Magdalena district; Ojo Caliente district, rare.

Chalcophanite. Hydrous manganese-zinc oxide. [$(Mn, Zn)O . 2MnO_2 . 2H_2O$]. A rare mineral, valuable as mineralogic specimens. Socorro County, Magdalena district, mined with smithsonite.

Gahnite (zinc-spinel). Zinc aluminate ($ZnAl_2O_4$). Santa Fe County, Cerrillos district.

Goslarite. Hydrous zinc sulphate ($ZnSO_4 . 7H_2O$). Grant County, Central district. Sierra County, Kingston district. Socorro County, Magdalena and Water Canyon districts.

Hydrozincite (zinc bloom). Basic zinc carbonate [$3Zn(OH)_2 . 2ZnCO_3$]. Luna County, Tres Hermanas district, with willemite and smithsonite. Socorro County, Magdalena district, with smithsonite.

Monheimite. Ferriferous smithsonite. Occurs in the Magdalena district, Socorro County, and probably also in other districts where smithsonite is common.

Smithsonite (dry-bone ore). Zinc carbonate ($ZnCO_3$). The common product resulting from the oxidation of zinc ores in limestone. Grant County: Carpenter and Central districts; Fierro-Hanover district, important; Pinos Altos district. Luna County, Cooks Peak, Florida Mountains and Tres Hermanas districts. San Miguel County, Willow Creek district. Santa Fe County, Los Cerrillos district. Socorro County: Magdalena district, important as ore and for museum specimens; Lemitar district.

Sphalerite (zinc blende, blende, black jack, mock-lead, false galena). Zinc sulphide (ZnS). Catron County, Mogollon district, with silver-copper ores. Dona Ana County, Modoc and Organ districts. Grant County: Burro Mountains, Carpenter and Central districts; Fierro-Hanover district, very important; Gold Hill, Pinos Altos, Steeplerock and White Signal districts. Hidalgo County, Fremont, Hachita, Lordsburg and Steins Pass districts. Lincoln County, Nogal district. Luna County, Cooks Peak, Florida Mountains and Tres Hermanas districts. Rio Arriba County: Bromide district, rare; Hopewell district. Sandoval County, Cochiti district. San Miguel County: Rociada district (?); Willow Creek district, most important mineral. Santa Fe County, Los Cerrillos, Santa Fe and New Placers districts. Sierra County, Kingston and Lake Valley districts. Socorro County: Magdalena district, very important; Lemitar Mountains, Mockingbird Gap and Water Canyon districts. Taos County, Red River and Twining districts.

Tallow clay. A brown tallow-like clay containing zinc, locally in economic amounts. Socorro County, Magdalena district.

Willemite. Zinc silicate (Zn_2SiO_4). An uncommon mineral. Grant County, Central district. Luna County, Tres Hermanas district, in oxidized zinc ores. Socorro County: Magdalena district, at one locality, associated with cerusite and native gold; Socorro Peak district (?). Probably more common as an oxidation product of zinc minerals than generally supposed.

Zincite (red oxide of zinc). Zinc oxide (ZnO). Luna County, Tres Hermanas district, reported.

MINING DISTRICTS

BERNALILLO COUNTY

Bernalillo County, the smallest county in New Mexico, is in the north-central part of the State and has an area of only 1,214 square miles. The part west of the Rio Grande lies at the eastern edge of the great Plateau province and is mainly underlain by Cretaceous strata. Tertiary and Quaternary sediments occur along the valley. The part east of the river contains the Sandia Mountains and the northern end of the Manzano Mountains.

TIJERAS CANYON DISTRICT

This district includes the Coyote, Carnuel, Hell Canyon, Soda Springs and La Luz sub-districts. These are situated in the Sandia and Manzano Mountains, which are separated by Tijeras Canyon.

The metals present are lead, silver and gold. A carload of ore was produced each year in 1909, 1910, and 1916. Production is valued at $2,792, segregated as follows: Gold, $490; silver, 134 ounces valued at $75; and lead, 42,638 pounds valued at $2,227.

The ore occurs in veins in granite and allied rocks of pre-Cambrian age and in the overlying Magdalena (Pennsylvanian) limestone. The veins are associated with a system of faults which traverse the west front of the mountains.[1]

CATRON COUNTY

Catron County, separated from Socorro County in 1921, covers an area of about 7,500 square miles at the western edge of the State between Socorro County and the State of Arizona. The surface rocks are chiefly Tertiary volcanic flows. The entire metal output of the county, which is valued at approximately $19,500,000, has come from the mines of the Mogollon district.

MOGOLLON (COONEY) DISTRICT[2]

The Mogollon, or Cooney, district is in the southwestern part of Catron County and is about 85 miles northwest of Silver City. It is in the Mogollon Mountains near the western border of the State.

The first claims were located in 1875 by James Cooney. Owing to Indian troubles no ore was shipped until 1879, but after that date mining activity increased rapidly. Production prior to

[1] Ellis, R. W., Geology of the Sandia Mountains: Univ. of N. Mex. Bull. 108, p. 40, 1922.
[2] Ferguson, H. G., Geology and ore deposits of the Mogollon mining district, New Mexico: U. S. Geol. Survey Bull. 787, 1927.

1904 had a value of approximately $5,000,000 and from 1904 to 1930 it amounted to $14,633,923, making a total of over $19,500,000. The district reached its maximum importance in 1913, when it produced gold, silver and subordinate amounts of copper and lead valued at $1,409,912. Production declined rapidly after 1917, and late in 1925 the district was shut down almost completely. The Cooney mine was one of the chief properties in the early history of the camp. The Last Chance, Fanny and Champion mines have been the chief producers. During the last 10 years of the active life of the district most of the mines were operated by the Mogollon Mines Co. Activity was resumed in 1931 when Ira L. Wright and associates of Silver City leased the Fanny mine and began mining operations.

The ore deposits of the Mogollon district are fault veins in Tertiary volcanic rocks consisting of rhyolite, quartz latite, andesite and accompanying pyroclastic rocks. The region is crisscrossed by faults which follow two main directions—one a little east of north and the other a little north of west—and which have broken the area into irregular blocks. With the exception of a large recent fault on the western mountain front, every important fault shows some mineralization. Most of the veins have prominent outcrops. The productive area is less than 2 miles long by a mile wide and lies just west of the town of Mogollon.

The ore occurs as shoots, commonly from 300 to 600 feet in drift length and about the same along the dip, and usually from 5 to 15 feet wide. Most of the veins show a sharp change from ore containing 8 ounces or more of silver to the ton to low-grade material carrying 3 ounces or less. In the average ore of the district the ratio of silver to gold is about 50 to 1.

Quartz and calcite are the chief gangue minerals. Fluorite is also present. The most abundant metallic minerals are pyrite, chalcopyrite, galena, sphalerite, bornite, argentite, stromeyerite and chalcocite. The ore shows fine colloform texture.

The known ore bodies have been definitely bottomed, but according to Ferguson[1] an enriched zone at water level is a possibility. It is also possible that primary ore bodies of workable grade exist at greater depth than has yet been reached, and that similar ore bodies occur at moderate depths in those veins whose outcrops are unpromising.

[1] Op. cit., p. 98.

Production of Metals in the Mogollon (Cooney) District, Catron County, 1904-1930

	Gold	Silver, ounces	Copper, pounds	Lead, pounds	Total Value
1904	$ 61,880	79,014	422,308	-----	$ 161,763
1905	97,158	240,943	295,175	-----	290,180
1906	127,907	268,567	------	-----	310,533
1907	105,413	418,338	150,000	-----	411,516
1908	116,418	278,939	------	-----	264,256
1909	111,464	249,413	46	49	241,167
1910	304,210	595,669	------	-----	625,871
1911	531,358	1,067,038	1,873	1,862	1,097,206
1912	524,858	1,093,158	184	386	1,197,197
1913	619,886	1,306,766	4,418	1,217	1,409,912
1914	629,102	1,410,327	------	590	1,409,035
1915	509,165	1,301,059	------	2,426	1,168,916
1916	373,068	1,008,483	858	3,232	1,037,084
1917	258,620	722,642	414	1,593	854,327
1918	119,710	302,902	235	282	422,690
1919	148,136	382,800	9,521	-----	578,643
1920	125,631	329,489	582	2,050	485,045
1921	126,791	310,774	------	-----	437,565
1922	142,133	322,460	------	-----	464,593
1923	179,351	398,714	------	-----	506,296
1924	230,960	618,094	------	-----	645,083
1925	163,322	449,699	------	-----	475,413
1926	12,444	28,404	24,400	-----	33,584
1927	4,678	3,591	------	-----	6,714
1928	4,189	16,800	17,000	-----	16,465
1929	15,287	40,437	15,187	-----	39,513
1930	19,270	61,621	2,400	1,000	43,356
Total 1904-1930	$5,665,409	13,306,141	944,601	14,687	$14,633,323

TAYLOR CREEK TIN DISTRICT[1]

The Taylor Creek tin deposits are on the west side of the Black Range about 70 miles southwest of Magdalena and 48 miles west of the Rio Grande. The boundary line between Sierra and Catron counties crosses the deposits. Stream tin was found in the district in 1918.

The tin occurs as cassiterite in veinlets in soft, kaolinized rhyolite, and as local disseminations in the walls. The cassiterite is chiefly the dense botryoidal variety, but red tabular crystals intimately mixed with specularite also occur. The veins are small and not persistent. The rhyolite, which is the oldest rock exposed in the district, is overlain by basalt, tuff, sandstone and conglomerate which are barren of tin deposits. The stream gravels of the district carry placer tin derived from the veins.

CHAVES COUNTY

Chaves County is practically devoid of known metal resources. Placer gold is reported to occur along the Rio Hondo,[2] presumably derived from the deposits of Lincoln County which adjoins Chaves County on the west.

[1] Hill, J. M., The Taylor Creek tin deposits, New Mexico: U. S. Geol. Survey Bull. 725, pp. 347-359, 1922.

[2] Schrader, F. C., Stone, R. W., and Sanford, Samuel, Useful minerals of the United States: U. S. Geol. Survey Bull. 624, p. 214, 1917.

COLFAX COUNTY

Colfax County is in northeastern New Mexico just south of the State of Colorado. It contains 3,798 square miles. The western boundary separating Colfax from Taos County lies along the crest of the Rocky Mountains, here known as the Sangre de Cristo Range. The rest of the county lies at the edge of the vast plateau that extends eastward from the foot of the range.

The main part of the Sangre de Cristo Range south of Elizabethtown is composed chiefly of Carboniferous strata, but north of this place pre-Cambrian rocks predominate. East of the main mountains is the Cimarron Range, which attains its greatest elevation in Baldy Peak near Elizabethtown and extends north and south for about 30 miles. It is composed mainly of monzonite porphyry which has domed the overlying sedimentary rocks. South of the monzonite are great basalt flows which rest on Cretaceous strata. These strata extend across most of the remaining parts of the county. In the northeastern part the Cretaceous rocks are locally covered by remnants of basalt flows.

The metal mining districts are grouped along the Cimarron Range, with Elizabethtown near the center of the group. Placer gold was found near what is now Elizabethtown in 1866. Lode deposits, including the famous Aztec mine, were discovered soon after, but most of the early work was placer mining. Dredge operations were instituted about 1900 but were soon discontinued. To 1930 the county produced $6,781,436 in gold, silver, copper and lead, of which over $6,000,000 represents lode and placer gold. Lode deposits have yielded a little over 55 per cent of the total gold produced. Production prior to 1904 was approximately $4,400,000.

Production of Metals in Colfax County, 1904-1930

	Gold		Silver, (Lode and Placer), ounces	Copper, pounds	Lead. pounds	Total Value
	Lode	Placer				
1904	$ 3,638	$ 90,639	67	----	----	$ 94,316
1905	445	31,994	181	----	----	32,549
1906	----	14,492	93	----	----	14,655
1907	----	11,914	83	----	----	11,969
1908	----	11,274	66	----	----	11,309
1909	1,705	16,037	127	----		17,808
1910	3,433	9,588	261	----	2,182	13,258
1911	31,547	9,860	1,254	5,587		42,770
1912	27,316	8,385	634	6,243	----	37,121
1913	15,588	4,550	254	1,147	134	20,475
1914	63,129	4,930	577	11,083	154	69,858
1915	350,745	2,631	2,483	14,092	787	357,138
1916	417,258	5,039	2,803	447	----	424,251
1917	342,994	5,739	2,381	4,784	930	352,081
1918	258.034	2,133	1,880	4,619	----	263,188
1919	238,656	3,885	1,634	----	----	244,371
1920	81,722	1,634	607	----	----	84,018
1921	5,361	3,447	52	----	----	8,860
1922	76,341	1,472	570	----	----	78,383
1923	48,725	1,811	430	592	----	50,975
1924	242	2,303	15	----	----	2,555
1925	51,688	970	432	----	----	52,958
1926	18,748	1,851	175	250	----	20,743
1927	32,962	2,155	353	1,687	----	35,538
1928	18,052	424	145	----	----	18,561
1929	----	----	----	----	----	----
1930	248	----	----	----	----	248
Total 1904-1930	$2,088,577	$249,157	17,557	50,531	4,187	$2,359,856

BALDY (UTE CREEK) DISTRICT[1]

The Baldy district, on the flanks of Baldy Peak, is the eastern continuation of the Elizabethtown district. The general geology of the two districts is essentially the same. The Pierre shale (Upper Cretaceous) and the Raton formation (early Tertiary) are the only sedimentary rocks exposed in the vicinity of Baldy. Quartz monzonite porphyry dikes and sills are common, and sills are particularly prominent in the shale.

The principal ore bodies lie at the unconformable contact between the basal conglomerate of the Raton formation and the underlying Pierre shale and are commonly localized near the crests of minor folds and at the intersection of small faults with the shale. Most of the ore occurs in the shale. In addition to native gold the ore carries a minor proportion of mixed sulphides associated with calcite, and tetradymite and molybdenite[2] have been reported. The ore is erratic in distribution and grade and is said to range in value from $5 to $250 in gold a ton. Small bodies of contact-metamorphic ores have been found.

CIMARRONCITO DISTRICT

The Cimarroncito district is about 14 miles southeast of Elizabethtown and lies near the crest on the east side of the

[1] Lee, W. T., The Aztec gold mine, Baldy, New Mexico: U. S. Geol. Survey Bull. 620, pp. 325-330, 1916.
Chase, C. A. and Muir, D., The Aztec mine, Baldy, New Mexico: Am. Inst. Min. and Met. Eng. Trans., vol. 68, pp. 270-281, 1923.
[2] Eardly-Wilmot, V. S., Molybdenum: Canada Dept. Mines, Mines Br., No. 592, p. 177, 1925.

Cimarron Range. No extensive bodies of good ore have been found, and production has been slight.

The explored mineral deposits of the district consist almost wholly of contact-metamorphic deposits in limestone near masses of intrusive monzonite porphyry. Quartz veins in the intrusive rock have been developed at one or two places. The intruded sediments are Pennsylvanian and Cretaceous in age. The contact-metamorphic ores are typical of the general class and are characterized by andradite garnet, epidote, quartz, calcite, specularite, magnetite, chalcopyrite and pyrite. The gold content is somewhat higher than ore of this class generally carries. The ore carries up to $10 in gold and 3 or 4 ounces of silver to the ton, and as much as 8 to 10 per cent of copper, but very little ore of such grade has been found.

ELIZABETHTOWN (MORENO) DISTRICT

The Elizabethtown district comprises a narrow strip of country extending east and west across the Cimarron Range. It includes the town of Elizabethtown, which is 35 miles northeast of Taos. The nearest railroad station is Ute Park, about 12 miles southeast on a branch line of the Atchison, Topeka & Santa Fe railway. Rich placer gold was found in the district in 1866 by prospectors who were sent to do assessment work on claims upon which copper float had been found. The resulting boom lasted many years, and only in recent years has the area become of secondary importance.

The rocks exposed in the Elizabethtown district consist of Upper Cretaceous sediments (chiefly Pierre shale) which have been faulted and later intruded by numerous dikes and sills of monzonite and quartz monzonite porphyries. The igneous rocks are part of the same general intrusion which is exposed in the Cimarroncito and Baldy districts, and which extends as far north as Costilla Peak.[1]

The gold deposits are of three types: quartz veins, contact-metamorphic deposits, and gold placers. The veins occur both in the monzonite and at the contact of sills of monzonite with the shale, but the contact seems to be the more common location. The veins are simple fissures and lodes in which several narrow parallel veinlets constitute an individual ore body. The lodes are more common in the porphyry. The veins range from a fraction of an inch to a few inches in thickness, and they may be traced up to a half mile in length. In composition they are essentially auriferous quartz-pyrite veins, but chalcopyrite and galena are present here and there in small amounts. Pyrrhotite is intergrown with pyrite in the shale. Oxidation is well advanced, and as a result a large part of the gold is free. Much of the ore as broken is said to have averaged $10 to $20 a ton, and richer ore has been found in some places.

[1] Darton, N. H., Geologic map of New Mexico: U. S. Geol. Survey, 1928. Scale, 1:500,000.

Contact-metamorphic deposits are less abundant and economically less important than the veins. The calcareous shales in contact with thick sills and stocks of porphyry have been altered to dark crystalline rocks composed largely of diopside and scapolite and some epidote, calcite, amphibole and magnetite. Pyrite, pyrrhotite and chalcopyrite are intergrown with magnetite. The gold content ranges in value from $1 to $80 a ton, but the ore on the whole is low grade.

The placers have been derived from these primary deposits, perhaps largely from the veins. Their production has been nearly as much as that of the lodes and for a number of years constituted the entire gold output of Colfax County. The placers of this region range from a few feet to over 300 feet in thickness, but for the most part they are relatively shallow. They have been worked by dredging, hydraulicking, ground sluicing and by simple hand methods. The gravel has been removed to bedrock in places.

POÑIL DISTRICT

The Poñil placers are east-northeast of Elizabethtown and northeast of Baldy Peak. The placer deposits have been derived from the gold veins of the Baldy district, perhaps mostly from the Aztec deposits. They are similar to those of the Elizabethtown district.

DONA ANA COUNTY

Dona Ana County is in central southern New Mexico and occupies an area of 3,821 square miles. It is bordered by Mexico and the State of Texas on the south, Luna and Sierra counties on the west, Sierra and Socorro counties on the north and Otero County on the east. The Rio Grande flows diagonally through it from northwest to southeast.

Most of the county lies in the Rio Grande valley. In the southwest part is a fairly large area of Quaternary basalt known as the West Potrillo Mountains. In the northwest part is a similar area of Tertiary and Quaternary volcanic rocks, known as the Sierra de Las Uvas. These mountains are a short distance south of the southern end of the Sierra Caballos which extends into Dona Ana County nearly to Rincon. Near the east edge of the county is a chain of mountain ranges which extends with but a single interruption the full length of the county. This chain consists of the San Andres, Organ and Franklin Mountains, named from north to south.

The Organ Mountains contain all the important mineral deposits of the county, with the exception of the manganese deposits near Rincon, and practically the entire production of the county has come from the mines of the Organ district. The value of the gold, silver, copper, lead and zinc produced in the county from 1904 to 1930 is $1,160,974.

Production of Metals in Dona Ana County, 1904-1930

	Gold	Silver, ounces	Copper, pounds	Lead, pounds	Zinc, pounds	Total Value
1904		24,101	40,000	1,531,488	-----	$ 87,103
1905	$ 6,710	21,776	96,058	327,707	30,000	52,150
1906	-----	34,051	434,000	1,207,193	-----	175,727
1907	6	25,612	776,125	675,189	-----	207,920
1908	-----	9,283	21,150	379,697	-----	23,660
1909	248	16,975	10,600	772,023	-----	43,650
1910	-----	15	-----	705	-----	39
1911	-----	111	353	1,561	-----	178
1912	17	1,790	6,685	26,129	-----	3,397
1913	30	1,232	10,189	9,557	-----	2,774
1914	927	3,564	78,180	29,897	-----	14,462
1915	2,426	8,335	241,749	19,170	-----	49,859
1916	503	7,948	206,187	34,696	106,679	73,144
1917	98	4,705	16,121	162,965	-----	22,391
1918	109	45,661	110,676	1,616,479	114,000	198,251
1919	-----	4,726	319,323	29,981	-----	66,276
1920	44	4,779	168,853	120,100	12,852	46,971
1921	-----	676	-----	20,000	-----	1,576
1922	-----	413	-----	12,576	-----	1,104
1923	-----	-----	-----	-----	14,000	952
1924	-----	300	8,893	2,064	-----	1,531
1925	-----	2,684	1,313	55,400	-----	6,868
1926	104	5,131	12,377	235,200	-----	23,855
1927	77	1,862	1,923	71,651	-----	5,899
1928	14	3,959	39,000	105,897		14,088
1929		9,516	28,665	326,238	-----	80,670
1930	3,113	1,587	17,000	11,000	-----	6,484
Total 1904-1930	$14,426	240,792	2,645,420	337,238	277,531	$1,160,974

GOLD CAMP (BLACK MOUNTAIN) DISTRICT

Gold Camp, generally considered part of the Organ district, is between Mineral Hill and Black Mountain and is several miles north of San Agustin Pass. It is about 8 miles east-northeast of Organ. The district has a small production to its credit.

The country rock is pre-Cambrian granite.[1] The ore occurs in narrow, sharply defined, quartz-filled veins which strike eastward and dip steeply. Many of them occur along dikes. The ore contains auriferous pyrite and subordinate chalcopyrite. Free gold occurs near the surface in a comparatively shallow zone of oxidation. Bismuth minerals are reported to occur with some of the ores.[2]

HEMBRILLO DISTRICT

The Hembrillo district, in Hembrillo Canyon in the San Andres Mountains, is a mile or two south of the Socorro-Dona Ana County line. Chalcocite is the principal ore mineral. The deposits are probably similar to those of the Goodfortune Creek district, Socorro County. Only a small amount of development work has been done.

[1] Darton, N. H., "Red Beds" and associated formations in New Mexico: U. S. Geol. Survey Bull. 794, plate 40, 1928.

. . . . . ., Geologic map of New Mexico: U. S. Geol. Survey, 1928. Scale 1: 500,000.

[2] Schrader, F. C., Stone, R. W., and Sanford, Samuel, Useful minerals of the United States: U. S. Geol. Survey Bull. 624, p. 209, 1917.

MODOC DISTRICT

The Modoc district, a sub-district of the main Organ district, is 6 miles south of the town of Organ. This district has produced lead ores intermittently since 1854 or earlier.

The ore occurs in a narrow zone of metamorphosed limestone adjacent to a belt of andesitic porphyry which lies between the limestone and quartz monzonite. The ore is characterized by an intimate intergrowth of galena and epidote and is poor in silver. A little pyrite and zinc blende accompany the galena.

ORGAN DISTRICT

The Organ Mountains consist mainly of a large intrusive mass of quartz monzonite. Pre-Cambrian granite overlain by westward-dipping Paleozoic strata occurs at the north end of the mountains, and a strip of Magdalena limestone extends for a number of miles along the foot of the northeastern slope.[1]

The Stephenson-Bennett mine, the most important mine in the district, was discovered in 1849. In the early days the ores were smelted in adobe furnaces at Las Cruces. Production from the district has continued to the present day, although in more recent years it has been so small that the district may be considered practically idle. Copper, lead, zinc, silver and minor amounts of gold and molybdenum have been produced.

The Organ district contains the following well-defined types of deposits:

(1) Fissure veins in intrusive rocks. These are usually narrow, sharply defined, quartz-filled veins which strike eastward and dip steeply. Most of them are on the east side of the range, and many occur along dikes. The ore contains galena, sphalerite and tetrahedrite and is silver bearing.

(2) Replacement veins in limestone. These deposits generally follow the stratification of the limestone, which is unaltered. The gangue is scant and consists of quartz, calcite, barite and fluorite. Argentiferous galena is the chief ore mineral. Pyrite, sphalerite and abundant wulfenite are also present. This type is best represented at the Stephenson-Bennett mine.

(3) Contact-metamorphic deposits. These deposits carry chiefly copper and occur as irregular masses, roughly following the stratification, for several miles along the main contact of quartz monzonite and limestone. The primary ore consists of chalcopyrite intimately associated with a gangue of garnet, epidote, quartz, calcite and specularite. Bismuth minerals are said to occur in workable quantities.[2] Zinc blende is present in places, and molybdenite is reported. Oxidation extends irregularly to depths of several hundred feet. The deposits of this class appear to contain very little gold and silver.

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[1] Darton, N. H., "Red Beds" and associated formations in New Mexico: U. S. Geol. Survey Bull. 794, pp. 197-198, 1928.

[2] Schrader, F. C., Stone, R. W., and Sanford, Samuel. op. cit., p. 209.

RINCON MANGANESE DISTRICT[1]

The manganese deposits in the vicinity of Rincon occur in Tertiary sandstone and conglomerate in the southern foothills of the Caballos Range. The ore consists of manganese oxides, chiefly psilomelane, in a gangue of barite and calcite, and occurs along numerous fault fissures of small displacement and along minor parallel fractures. Recent sand and gravel deposits derived from the adjacent slopes occur south of the vein deposits, and some of this detrital material contains considerable fragmental psilomelane.

This district produced 203 long tons of ore containing 40 per cent or more of manganese and 268 long tons of ore containing 15 to 40 per cent in 1916, 1917 and the first six months of 1918.[2]

TEXAS DISTRICT

The Texas district is a sub-district of the main Organ district and is about 10 miles southeast of Organ. The deposit is said to be a vein in the intrusive rock and contains pyrite in a quartz gangue. Molybdenite is reported. Gold is the chief metal produced.

EDDY COUNTY

Eddy County is in southeastern New Mexico north of the State of Texas and east of Otero County. Its metal deposits are unimportant. Sixty-seven tons of copper ore containing 6,256 pounds of copper valued at $844, and 3 ounces of silver valued at $2, was mined in 1914, 1926 and 1927 from deposits in Chupadera limestone west of Carlsbad.

GRANT COUNTY

Grant County is in southwestern New Mexico adjacent to the State of Arizona and has an area of 3,981 square miles. It is bounded by Catron County on the north, Sierra and Luna counties on the east and Luna and Hidalgo counties on the south. Hidalgo County was part of Grant County until July, 1920. The boundary between Grant and Sierra counties follows the crest of the Mimbres or Black Range, which may be said to form the eastern margin of the Plateau Province. In this region the general plateau character is due to thick Tertiary volcanic flows into which the Gila and Mimbres rivers and their tributaries have cut deep valleys. In the region around Silver City, Pinos Altos, Santa Rita and Hanover, erosion has exposed the underlying Cretaceous and Paleozoic sediments which are broken by faults and intruded by masses of quartz diorite and granodiorite porphyry. The Big Burro Mountains, an extensive mass of pre-Cambrian rocks, rise out of the alluvium southwest of this area.

[1] Wells, E. H., Manganese in New Mexico: N. Mex. Sch. of Mines, Min. Res. Survey, Bull. 2, pp. 35-39. 1918.
Jones, E. L., Jr., Deposits of manganese in New Mexico: U. S. Geol. Survey Bull. 710, pp. 41-43. 1919.
[2] Wells, E. H., op. cit., p. 82.

Grant County ranks first among the counties of the State in metallic wealth and has produced about 70 per cent of the State's entire output. The value of gold, silver, copper, lead and zinc produced in this county from 1904 to 1930 and from Hidalgo County from 1904 to 1919 was $246,684,027. Ores of iron, manganese, radium, uranium and vanadium have been produced also. Other metals occurring in the county are molybdenum, bismuth, cobalt and nickel.

Production of Metals in Grant County, 1904-1930[a]

	Gold		Silver,	Copper,	Lead,	Zinc,	Total Value
	Lode	Placer	ounces	pounds	pounds	pounds	
1904	$ 60,347	$ 8,081	74,793	4,428,608	179,142		$ 695,099
1905	35,064	10,943	86,629	5,291,222	321,035	257,203	954,026
1906	97,519	2,290	163,987	6,388,830	710,895	144,656	1,492,069
1907	109,260	3,782	224,279	8,046,315	1,394,390	73,729	1,948,582
1908	42,168	3,514	95,477	5,242,767	244,589	251,070	810,403
1909	34,242	3,584	74,198	5,176,585	215,070	203,278	760,590
1910	63,291	2,641	156,557	4,404,394	257,953	1,285,500	790,598
1911	112,241	4,043	221,882	3,918,928	694,247	306,895	772,481
1912	163,645	2,551	356,057	32,952,133	2,309,732	3,135,000	6,142,526
1913	102,971	1,646	206,215	53,436,177	446,805	2,553,322	8,674,423
1914	379,300	21,560	304,679	58,259,113	570,513	3,734,768	8,448,810
1915	363,104	1,979	508,552	72,487,200	2,251,383	6,083,580	14,168,358
1916	417,666	2,009	549,907	87,784,545	2,561,638	14,084,843	24,440,634
1917	401,293	3,153	487,558	101,373,641	3,224,477	13,335,127	30,118,686
1918	269,380	672	338,833	96,939,381	3,158,493	11,876,428	25,857,920
1919	242,317	1,074	336,499	50,075,911	1,587,416	4,567,329	10,351,937
1920	89,212	554	81,299	51,015,864	1,038,825	6,177,840	10,148,812
1921	14,900	2,368	106,272	13,634,563	96,844	95,000	1,891,507
1922	45,992	2,079	150,844	28,438,896	1,123,782	1,333,440	4,175,980
1923	83,988	1,300	94,392	56,825,912	1,574,727	13,061,000	9,514,477
1924	74,430	1,042	43,064	69,498,084	1,301,812	16,921,000	10,412,584
1925	98,263	529	80,319	70,707,802	2,486,110	15,033,000	11,553,841
1926	115,886	639	118,485	75,909,600	3,122,300	14,767,000	12,175,113
1927	106,383	693	143,434	67,237,878	2,774,364	10,270,000	9,828,630
1928	115,358	923	153,453	81,131,090	2,822,328	15,512,000	12,998,855
1929	134,903	491	397,771	88,538,239	8,044,858	22,926,000	17,950,078
1930	78,110	1,190	413,379	57,604,600	8,047,500	30,783,000	9,607,008
Total 1904-1930	$3,791,233	$85,330	5,968,804	1,256,748,178	52,561,327	208,717,108	$246,684,027

[a] Includes production of Hidalgo County from 1904 to 1919. Figures for 1920 to 1930 represent production of Grant County only.

BLACK HAWK (ALHAMBRA, BULLARD'S PEAK) DISTRICT

The old camp of Black Hawk is in the northern part of the Big Burro Mountains, about 12 miles northwest of Tyrone and about 15 miles west of Silver City. Rich silver float is said to have been discovered here in 1881. The district was booming from 1885 to 1887. Mining continued up to 1893, but nothing of consequence has been done since. The latest reported production was several cars of silver ore shipped in 1921. Production of the camp amounts to perhaps $1,000,000.[1]

The deposits of the district are veins in pre-Cambrian gneiss, some of them parallel to or otherwise associated with dikes of diorite porphyry. The ore is said to have consisted of dolomite and barite associated with much native silver and argentite and a little horn silver. Nickel and cobalt occur with the silver ore.[2] (See pages 25 and 33.)

[1] Lindgren, Waldemar, Graton, L. C., and Gordon, C. H., The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, p. 324, 1910.

[2] Hillebrand, W. F., Mineralogical Notes: Proc. Colo. Sci. Soc., vol. 3, pt. 1, p. 46, 1889. Waller, E. and Moses, A. J., A probably new nickel arsenide: School of Mines Quarterly, vol. 14, p. 49, 1892.

The veins are narrow and the metal content erratic. The principal vein has been opened to a vertical depth of almost 700 feet, and native silver is said to have been found at that depth.

BURRO MOUNTAINS (TYRONE, COW SPRINGS) DISTRICT[1]

Copper was discovered in the Burro Mountains in 1871, and several periods of activity and idleness followed. Two smelters were erected, but they were unsuccessful. Interest was revived in the region by important discoveries in 1902. In 1905 the Phelps Dodge Co. (now the Phelps Dodge Corp.) purchased the property of the Burro Mountain Copper Co. at Leopold and in 1912 acquired the property of the Chemung Copper Co. at Tyrone. The mines were developed for large-scale operations, and a concentrating mill with a capacity of 2,000 tons per day was constructed. The district reached its maximum importance in 1918 when it produced 17,000,000 pounds of copper. The mines of the Phelps Dodge Corp. were shut down in March, 1921, but a small production has been continued by leasing and leaching operations. Heap leaching of ore was begun early in 1917, but it was discontinued after 3 years of intermittent operation, owing to lack of water. In 1921, shortly after the mines were shut down, leaching operations were started on the waste dump, which contains nearly 1,000,000 tons of low-grade material, and these operations were continued until late in 1928. Meanwhile laboratory leaching experiments on mixed oxide and sulphide ores from the mine had been so successful that a small plant was erected in 1927, operating for about 2 years. Approximately 80,000 tons of ore has been shipped by lessees since the company ceased active mining in 1921.

Developed ore reserves amount to more than 10,000,000 tons averaging about 2 per cent copper.

The Burro Mountains are made up of two distinct mountain masses separated by the Mangas Valley. The Little Burro Mountains are on the northeast side of the valley and north of Tyrone. They trend northwestward along a tilted fault block that has been elevated on its west side by a strong northwest fault. The range consists of pre-Cambrian granite and Cretaceous sediments intruded by andesitic and rhyolitic rocks and overlain by Tertiary volcanic flows.

The Big Burro Mountains are southwest of the valley and consist of a pre-Cambrian granite complex intruded by a large mass of quartz monzonite porphyry. Part of the quartz monzonite mass is covered by Quaternary gravel, but the exposed part is about 5 miles long and 4 miles wide.

Three classes of ore deposits occur in the district: (1) quartz veins, (2) irregular sulphide-impregnated fracture zones

[1] Paige, Sidney. Metalliferous ore deposits near the Burro Mountains, Grant Co., New Mexico: U. S. Geol. Survey Bull. 470, pp. 131-150, 1911.
...... U. S. Geol. Survey Geol. Atlas, Silver City folio (No. 199), pp. 15-17, 1916.
......, Copper deposits of the Tyrone district, New Mexico: U. S. Geol. Survey Prof. Paper 122, 1922.
Somers, R. E., Geology of the Burro Mountains copper district, New Mexico: Am. Inst. Min. Eng., Trans. vol. 52, pp. 604-644, 1915.

in the pre-Cambrian rock, and (3) secondarily enriched deposits of disseminated sulphides in highly fractured parts of the quartz monzonite and adjacent granite. Class 3 is by far the most important group.

Quartz veins have been mined chiefly at the southeastern end of the Little Burro Mountains about 1¾ miles north of Tyrone. These veins are simple, well-defined fissures in pre-Cambrian granite. The ores contain pyrite, chalcopyrite, sphalerite, galena and silver chloride. Manganese oxides are locally very abundant, and enrichment of gold and silver has been important in the upper parts of the veins. Silver and gold are the chief metals produced.

Iron and copper sulphides and gold occur in fairly well-defined fracture zones at a number of places within the pre-Cambrian area. Bismuth minerals are present locally. The gold-bearing quartz-sulphide stringers have been surficially enriched, but the zone of oxidation is shallow.

The secondarily enriched copper deposits in monzonite and granite, which have yielded nearly all the copper produced and to which the district owes its importance, are in the northeast foothills of the Big Burro Mountains. The quartz monzonite porphyry and the adjacent granite are intensely fractured in places. The area of fractured rock is roughly triangular with the apex southwest of Leopold. The zone of greatest fracturing lies between Leopold and Tyrone and forms roughly the northwest side of the triangle. The primary ore was deposited in these fractures and in the wall rock between. Fracturing diminishes toward the south and the richness of the disseminated ores likewise diminishes in this direction.

Sulphides have been leached from the ore-bearing rock near the surface, and much of this rock has been thoroughly cleansed of its copper. Leaching extends locally to depths of 700 feet or more and is deepest near strong veins and faults. An irregular chalcocite zone having a maximum thickness of 300 feet underlies the zone of oxidation and leaching. The chalcocite ore carries about 2 to 3 per cent of copper. A number of unconnected ore bodies of this type have been developed by churn drilling. They range in size from half a million to several million tons. Below the chalcocite zone is low-grade primary material (protore), carrying pyrite and very small amounts of chalcopyrite and sphalerite. A little molybdenite is also present.

The chalcocite ore also has been subjected to some oxidation and leaching. The present water level stands at 300 to 500 feet below the surface and shows no close relation to the zone of chalcocite enrichment. Chalcocite ore is found above and below the water level. The depth to which oxidation has penetrated the rocks increases northeastward from Leopold to Tyrone. At Tyrone the chalcocite zone lies at considerable depths, whereas at

Leopold this zone is at some places 50 feet or less from the surface.

No primary material or protore, which carries only a fraction of one per cent of copper, has been mined in the district. The material considered ore carries at least 2 per cent of copper, but this is an economic limit and varies with mining costs and the price of the metal.

Production of Metals in the Burro Mountain (Tyrone) District, Grant County, 1904-1929

	Gold	Silver, ounces	Copper, pounds	Lead, pounds	Total Value
1904	$ -----	------	973,231	-----	$ 124,574
1905	-----	------	1,804,416	-----	281,489
1906	-----	------	2,608,005	-----	503,345
1907	-----	------	2,163,810	-----	432,762
1908	271	387	801,841	-----	106,319
1909	284	2,160	1,160,838	-----	152,316
1910	421	1,769	80,205	-----	11,562
1911	558	3,623	28,089	-----	5,989
1912	-----	63	51,583	-----	8,550
1913	2	19	15,155	-----	2,362
1914	-----	739	285,014	-----	38,316
1915	-----	3,558	1,406,286	-----	247,904
1916	1,426	23,491	8,392,329	-----	2,081,396
1917	5,354	41,523	14,574,355	-----	4,018,368
1918	5,960	50,323	17,100,044	-----	4,279,994
1919	2,129	16,275	6,101,102	-----	1,155,162
1920	2,160	27,656	6,605,669	-----	1,247,748
1921	2,357	18,184	4,496,124	-----	600,541
1922	-----	------	------	-----	------
1923	21	724	2,374,163	-----	349,617
1924	-----	------	2,665,093	-----	349,127
1925	-----	664	1,890,662	----	268,935
1926	445	2,476	678,250	20,000	98,545
1927	873	4,993	250,687	-----	36,544
1928	523	1,805	889,347	-----	129,645
1929	1,158	3,724	1,085,131	-----	194,126
Total 1904-1929	$23,942	204,156	78,481,429	20,000	$16,725,236

CAP ROCK MOUNTAIN MANGANESE DISTRICT[1]

The Cap Rock Mountain district is about 20 miles north of Lordsburg, in the vicinity of Cap Rock Mountain. The manganese ore occurs as veins in quartzite and Gila conglomerate. It is largely psilomelane.

CARPENTER (SWARTZ) DISTRICT

The Carpenter district is on the western slope of the Black Range and about 6 or 7 miles southwest of Kingston. The district has been known for many years, but mining and development work has been intermittent. The old Royal John mill was operated for a few months in 1927, and it and the Royal John mine were acquired and operated in 1928 by the Asarco Mining Co. The district has been inactive since 1928.

The ore of the district is somewhat irregularly distributed along shear zones in crystalline lower Paleozoic (Ordovician) limestone. It consists chiefly of galena, pyrite and subordinate sphalerite in a quartz gangue. The ore is low grade and carries little or no gold or silver.

[1] Wells, E. H., op. cit., pp. 52-53.

CENTRAL DISTRICT[1]

The Central district has been recently studied under a cooperative agreement between the United States Geological Survey and the State Bureau of Mines and Mineral Resources of the New Mexico School of Mines, and a detailed report on the geology and ore deposits of the district is in preparation. The district includes a number of small mines and prospects around the town of Central, which is 7 miles east of Silver City and a mile south of Fort Bayard. The Hanover and Santa Rita areas are sometimes included in the Central district, but since these are geologically distinct from the region around Central they are described as separate districts, following the usage of the United States Geological Survey.[2] Production statistics are included in those for Santa Rita.

The most important mine in the Central district is the Ground Hog mine[3] of the Asarco Mining Co. near Vanadium. This deposit has been developed within the last few years and has been producing argentiferous zinc-lead-copper ore steadily. Total production of the mine up to November 1, 1930, was approximately 123,260 tons of ore valued at about $2,250,000. Prior to development of the Ground Hog mine, the Lucky Bill mine, adjacent to the Ground Hog and on the same vein, was the largest producer. This mine, now the property of the Black Hawk Consolidated Mines Co., is said to have produced ore, chiefly argentiferous lead carbonate, valued at about $3,000,000.[4]

The country rock consists of quartz diorite porphyry sills intruded into Colorado (Upper Cretaceous) sandstone and shale. The ore occurs in veins, which cut both sedimentary and igneous rocks and which carry copper, lead, zinc, and traces of gold.

The Ground Hog deposit is situated in a saddle underlain by quartz diorite and bounded on the east and west by Tertiary rhyolite, gravels and tuffs which are later than the ore. Dikes of granodiorite porphyry cut the quartz diorite. The ore occurs along a gently-dipping wide fault zone parallel to the general northeastward-trending fault system of the district. One large principal vein and a number of minor parallel veins have been developed. Other veins occur in the adjacent quartz diorite.

The ore is chiefly in the quartz diorite, but locally granodiorite forms one or both of the walls. The Colorado shale-sandstone series is present locally in the fault zone in the vicinity of the veins. The quartz diorite adjacent to the vein is silicified, sericitized and pyritized, and generally altered beyond recognition. The granodiorite, on the contrary, is nearly everywhere comparatively fresh.

[1] Paige, Sidney, U. S. Geol. Survey Geol. Atlas, Silver City folio (No. 199), areal geology and structure sections maps, 1916.

[2] Lindgren, Waldemar, Graton, L. C., and Gordon, C. H., The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, pp. 305, 317-318, 1910.
Hill, J. M., The mining districts of the western United States: U. S. Geol. Survey Bull. 507, pp. 231-232, 234, 1912.

[3] Lasky, S. G., Geology and ore deposits of the Ground Hog mine, Central district, Grant County, New Mexico: N. Mex. Sch. of Mines, State Bur. of Min. and Min. Res. Circular No. 2, 1930.

[4] Wright, Ira L., Personal communication.

The primary ore consists of a massive intergrowth of sphalerite, chalcopyrite and galena, and is argentiferous. Pyrite is common in the ore, usually as well developed crystals. Locally the ore has a suggestion of banding in zincy and leady streaks. Gangue is scarce and consists chiefly of quartz. The ore breaks clean from the walls, which show but little evidence of impregnation except by pyrite.

Some bonanza lead carbonate ore and a little vanadium ore were mined from this vein at and near the surface. Native copper and native silver were fairly common in parts of the oxidized zone.

Nearly all the arroyos of the district contain placer gold, and small quantities have been obtained by hand methods of placer mining.

CHLORIDE FLAT (SILVER CITY) DISTRICT[1]

Chloride Flat is a narrow shallow valley 1½ miles nearly due west of Silver City, which was founded following the discovery of silver ores at this place in 1871. Mining was abandoned in 1893 because of the low price of silver, but since then small shipments have been made from time to time. The latest reported shipment was a carload of gold and silver ore in 1925. The value of the production from this district is about $4,000,000.

Chloride Flat is one of the few places in New Mexico at which an excellent section of lower Paleozoic rocks is exposed. The pre-Cambrian basement is overlain successively by Cambrian quartzite, Ordovician and Silurian limestones, Devonian shale, Carboniferous limestone and Cretaceous quartzite and shale, all of which dip to the east.[2] The strata are cut by porphyry dikes and sills.

The ore bodies are extremely irregular and occur mainly in the upper part of the Fusselman (Silurian) limestone immediately beneath the Percha (Devonian) shale. Various oxidized lead and silver minerals, abundant pyrolusite, and some galena, magnetite and limonite occur in the ores. Silver chloride was the chief silver mineral; native silver and argentite (?) also were present. Lead was not an important constituent.

FIERRO-HANOVER DISTRICT[3]

The iron ores of the Fierro-Hanover district have been mined almost continuously since 1891, the year in which the Atchison, Topeka & Santa Fe railway reached Hanover. During the early years of production the ore was shipped to the smelters at El Paso, Tex. and Socorro, N. Mex. for use as flux. Prior to

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[1] See also Silver City manganese district, p. 65.

[2] Paige, Sidney, U. S. Geol. Survey Geol. Atlas, Silver City folio (No. 199), areal geology map, 1916.

[3] Paige, Sidney, op. cit., p. 15.

Kniffen, L. M., Mining methods of the Hanover Bessemer Company: Mng. Cong. Jnl., vol. 13, pp. 785-788, 1927.

. . . . . ., Mining and engineering methods and costs of the Hanover Bessemer Iron and Copper Co., Fierro, New Mexico: U. S. Bur. Mines Inf. Cir. 6361, 1930.

this a little magnetite float had been gathered and shipped by ox-team to Silver City and thence by railroad to Pueblo, Colo. In 1914 the important deposits were acquired by the Hanover Bessemer Iron & Copper Co., which several years later became a subsidiary of the U. S. Smelting, Refining & Mining Co. The first contract with the Colorado Fuel & Iron Co. at Pueblo, Colo. was arranged about 1900, and this company has smelted nearly all the iron ore since produced. Total production of iron ore has been approximately 4,000,000 long tons. Shipments in recent years have amounted to 200,000 tons annually. Part of the ore is run through a magnetic cobbing plant at Fierro, which raises the iron content about 10 per cent.

Exploitation of the zinc ores, the most important ores of the district, began about 1891,[1] at deposits later acquired by the Empire Zinc Co. This company has mined and milled a large tonnage of ore from its mines in the immediate vicinity of Hanover. In 1920 it acquired the Republic mine, southeast of Hanover, which has yielded an important production since that date. The ores were first treated at an electro-magnetic mill at Hanover, but in 1927 a modern flotation mill was placed in operation. The zinc concentrates produced are shipped to the company's zinc oxide plant at Canon City, Colo. In the period from 1925 to 1928 a moderate amount of zinc ore was developed at the Black Hawk mine southwest of Hanover, and in 1928 the Black Hawk Consolidated Mines Co. built a flotation mill[2] to handle ores from its own property and from other mines in the district. Most of the ore from the Ground Hog mine of the Asarco Mining Co., in the adjacent Central district, has been treated at this mill, which in 1931 and 1932 operated entirely on this ore. In 1927 the Peru Mining Co., a subsidiary of the Illinois Zinc Co., acquired the holdings of the Hanover Copper Co. east of Hanover and began mining and development operations. A mill to treat its own ores and do custom milling was constructed by this company at Wemple, near Deming, in 1928.

Production of zinc from the Fierro-Hanover district from 1904 to 1930 is included in the combined statistics for the Central district, page 61. The production shown in the table is 188,907,338 pounds worth approximately $14,000,000. Over 90 per cent of this zinc came from the Fierro-Hanover district. The zinc and iron mines suspended operations in the spring of 1931, but the Peru Mining Co. resumed operations on a moderate scale late in 1932.

Copper ores at the Hanover mine were probably known to the Indians at an early date, and about the middle of the nineteenth century this mine is said to have been producing more copper than the Santa Rita mines. The copper deposits are of minor importance.

[1] Blake, W. P., The zinc ore deposits of southwestern New Mexico: Amer. Inst. Min. Eng. trans., vol. 24, pp. 187-195, 1895.
[2] Wright, I. L., Milling methods and costs at the Black Hawk Concentrator, Hanover, New Mexico: U. S. Bureau Mines Inf. Circ. 6359, 1930.

The sedimentary rocks in the vicinity of Hanover and Fierro are intruded and domed up by a large stock of granodiorite. The exposed part of the stock is about 2½ miles long, north to south, and about a mile wide. The sedimentary rocks consist of the Bliss sandstone (Cambrian), El Paso limestone (Ordovician), Fusselman and Montoya limestones (Ordovician and Silurian), Percha shale (Devonian), Lake Valley limestone (Mississippian), Lower and Upper Magdalena formations (Pennsylvanian), which with the underlying Lake Valley formation were formerly called the Fierro limestone, Abo (?) formation (Permian), Beartooth quartzite (Upper Comanchean), and Colorado formation (Cretaceous). The sedimentary rocks are underlain by pre-Cambrian rocks, chiefly granite and schist. A laccolithic sill of quartz diorite porphyry has intruded the Percha shale on the west flank of the dome, and other smaller sills occur at several horizons. These are earlier than the stock. The sedimentary and igneous rocks have been intruded by many granodiorite dikes and by post-ore Tertiary quartz latite dikes. The rocks are much faulted, the important faults trending northeast or north, and many of the dikes were intruded along fault fissures.

The sedimentary rocks surrounding the stock have been subjected to profound igneous metamorphism, and large replacement sulphide and iron-oxide ore bodies have been formed. The metamorphic zone is from a few hundred feet to several thousand feet wide. The contact silicates include garnet, hedenbergite, epidote, zoisite, diopside, wollastonite, serpentine and ilvaite. The ore minerals include magnetite, specularite, pyrite, pyrrhotite, chalcopyrite, chalmersite, sphalerite and galena. In general, the silicates were formed in the early stage of metamorphism and ore deposition, the iron oxides next, and the sulphides during later stages. The limestones and dolomites of the sedimentary rocks were most affected, but some of the earlier dikes were also metamorphosed. The chief alteration minerals in the igneous rocks are zoisite, epidote, sericite and quartz. Serpentine and wollastonite are confined largely to the lower Paleozoic dolomitic sediments, while garnet, epidote, ilvaite and hedenbergite occur chiefly in the Lake Valley limestone and Magdalena formation. Magnetite and specularite as a rule occur adjacent to or within a short distance of the stock and the sulphides at varying distances from it. Magnetite and sulphides are found in all the sedimentary rocks. Sphalerite is most abundant at distances of a few hundred to a thousand feet from the intrusion, but in places nearly pure sphalerite bodies have formed at greater distances. Galena is prominent here and there in the outer part of the sphalerite zone. Sphalerite and galena occur in the outermost zone of mineralization, and silver is moderately important. Silicification and recrystallization of the limestones have occurred in places, and the upper crinoidal member (Hanover limestone) of the Lake Valley limestone is coarsely crystalline in nearly all parts of the district.

The most important iron deposits are at the Jim Fair and Republic mines of the Hanover-Bessemer Iron & Copper Co., near Fierro in the northern part of the district. The iron ore is chiefly in the El Paso limestone and is adjacent to the granodiorite stock. It forms irregular lenticular masses which are roughly parallel to the contact and which range in thickness from 5 to 200 feet, the average being about 40 feet. Replacement of the limestone beds by ore has been erratic, and at many places beds of ore are separated by beds of altered, partly mineralized rock. Where the ore beds merge, a wide zone of good ore results. The dip of the ore bodies is generally 50° to 60° away from the granodiorite contact and appears to flatten with depth.

The iron ores consist essentially of magnetite and subordinate specularite. Some bodies of ore near the chemical composition of pure magnetite have been mined. Chalmersite,[1] pyrite, chalcopyrite, sphalerite and occasionally molybdenite are present locally in minor amounts. The magnetite ore normally contains about 0.6 per cent of copper, and at many places secondary ores of copper, which represent copper leached from the primary magnetite bodies, lie between the iron ore and the igneous rock. An average partial analysis of concentrates obtained from ore mined near the surface is as follows: Iron, 51 per cent; phosphorus, 0.058 per cent; silica, 7.28 per cent; manganese, 0.72 per cent; alumina, 1.42 per cent; lime, 1.41 per cent; magnesia, 13.38 per cent; copper, 0.37 per cent; sulphur, 0.38 per cent. The magnesia presumably represents the original magnesia content of the dolomitic sedimentary rocks.

The important zinc deposits are in the southern part of the district and occur chiefly in the upper crystalline member (Hanover limestone) of the Lake Valley limestone and subordinately in the Magdalena formation. The ore occurs in tabular, veinlike, podlike and pipelike bodies. It consists of massive sphalerite with which is associated small amounts of pyrite, chalcopyrite and galena. Garnet, epidote, and particularly hedenbergite are characteristic gangue minerals. Much of the ore occurs adjacent to bodies of massive garnet or along dike contacts. At the Hanover mines of the Empire Zinc Co. the Hanover limestone is largely altered to garnet for several hundred feet from the main stock, and large bodies of high-grade zinc ore occur as a replacement of this limestone adjacent to the garnetized portion. Other ore bodies occur in the limestone along dikes and faults. At the Republic mine of this company the ores occur mainly adjacent to dikes and faults, and here and there the Hanover limestone bordering the ore has been converted into massive

[1] Schwartz, G. M., Chalmersite at Fierro, New Mexico: Econ. Geol., vol. 17, pp. 270-277, 1928.

garnet. The unoxidized ore produced from the mines of the Empire Zinc Co. is said[1] to average 17.49 per cent of zinc, 6.19 per cent of iron, 0.13 per cent of lead, and 49.77 per cent of insoluble. At the Black Hawk mine the zinc ores mined have been pipelike and irregular bodies in the Lake Valley and Magdalena formations, and the known zinc ore bodies of the Peru mine are irregular replacement bodies in these formations. The sulphide ore of the Black Hawk mine averages about 12 per cent of zinc, 5.0 per cent of lead, 0.6 per cent of copper, 2.5 ounces of silver a ton and a trace of gold.

Near the surface the sphalerite of the zinc ore has been oxidized, and large quantities of smithsonite and a little calamine have been mined. The oxidized ore is said[2] to contain about 30 per cent of zinc. In part it was deposited in open cavities and fractures of different sizes and shapes, ranging from minute veinlets to large fissures and tortuous openings in the limestone, but most of it forms irregular sheetlike deposits which are parallel to the bedding of the limestone and range up to 40 feet in thickness, 150 feet in width, and 400 feet in length. Gossans containing the limonite boxwork characteristic of oxidized hedenbergite are considered fairly reliable guides to underlying bodies of zinc ore.

FIERRO MANGANESE DISTRICT[3]

The Fierro Manganese district is about 2 miles northeast of Fierro. The ore, which consists of manganite, wad, limonite and a little manganiferous calcite, occurs along a fissure and as replacement bodies in the Fierro limestone. Only a small amount of ore has been exposed, and no shipments have been made.

FLEMING (BEAR MOUNTAIN) DISTRICT[4]

Fleming Camp is about 5 miles northwest of Silver City. Most of the mining at this place occurred in the eighties and early nineties. Total production probably amounts to about $300,000.

The ore is reported to have occurred in many irregular pockets in the Beartooth (Cretaceous) quartzite which at Fleming Camp overlies the Fusselman (Silurian) limestone. The silver, which was the important metal, was in the form of silver chloride, native silver and argentite.

GEORGETOWN (MIMBRES) DISTRICT[5]

The Georgetown district is about 3 miles east of Fierro and just west of the Mimbres River. Silver was discovered here in 1866. The camp was booming in 1875, but mining was stopped

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[1] Schmitt, Harrison, The Central mining district, New Mexico: Am. Inst. Min. & Met. Eng. Contrib. 39 (Class I, Mining geology), p. 18, 1933.
[2] Idem, p. 11.
[3] Wells, E. H., Manganese in New Mexico: N. Mex. Sch. of Mines Min. Res. Survey Bull. 2, pp. 51-52, 1918.
[4] Paige, Sidney, U. S. Geol. Survey Geol. Atlas, Silver City folio (No. 199), pp. 14-15,
[5] Paige, Sidney, op. cit., p. 14.

with the fall in the price of silver in the early nineties. The principal mines were the Naiad Queen, Commercial and MacGregor, all owned by the Mimbres Mining Co. Ore too low grade to be shipped was treated in a concentrating mill. The camp has been virtually abandoned for many years. Its production has been estimated to have a value of about $3,500,000.

The ore mined occurred in the Fusselman limestone directly below the Percha shale and along and near dikes. The limestone is much silicified and is vuggy in places. The ore was quite pockety, and the stopes are irregular in shape and direction. The ore was oxidized silver ore which was valuable chiefly for its cerargyrite content, but it contained some native silver and argentite. Argentiferous galena was mined in small amounts. Other minerals reported include cerusite, bromyrite, pyargyrite and vanadinite.

GOLD HILL DISTRICT

The Gold Hill district is about 16 miles northeast of Lordsburg in the large area of pre-Cambrian rocks south of the Big Burro Mountains. Gold is said to have been discovered in this district in 1884. Two stamp mills were erected and operated until the oxidized ores appeared to be exhausted. Later, cyanidation was successfully used. Gold-silver bullion has been shipped in recent years, the latest shipment being in 1927. The mining press reported shipments of base-metal ores in 1932.

The veins, which are believed to be of pre-Cambrian age, are of massive quartz which in places carries much pyrite and some galena. The ore is partly oxidized. Early operations were on ores said to have run $15 to $40 a ton in gold.

According to E. H. Wells,[1] gold is insignificant in the northern part of the camp, and the ore is mined for its silver content. The ore minerals consist of argentiferous galena, pyrite, sphalerite, native silver and cerusite, and almost invariably the highest grade silver ore is associated with abundant galena and pyrite in the sulphide zone and with cerusite and limonite in the oxidized zone. Concentrates and ore which netted about $43,000 were shipped from this part of the district in 1920 and 1921 by the Co-operative Mining Co.

HACHITA (EUREKA) DISTRICT

This district is described under Hidalgo County.

LONE MOUNTAIN DISTRICT[2]

Lone Mountain is an isolated group of three low hills about 6 miles southeast of Silver City. Rich silver ore is said to have been discovered in these hills in 1871. Some mining was done, and a mill was erected, but operations ceased after two or three years. A new discovery of silver ore was made in 1920, and ore

[1] Private Report.
[2] See also Silver City manganese district.

was shipped in 1921, 1922 and 1923. Lead was produced with the silver in these later operations.

The ore lies chiefly in fractures in the Fusselman (Silurian) limestone. The most common ore mineral was silver chloride, and the richest ore carried also wire silver and argentite (?). The veins are narrow and the metal content not persistent.

Manganiferous iron ore similar to that at Boston Hill occurs in the Lone Mountain district. A small amount of this ore was mined during the World War.

MALONE DISTRICT

Malone is about 13 miles nearly due southwest from Tyrone and near the Hidalgo County line. Most of the mining activity occurred in the eighties. The camp has been dead for many years, except for some recent small-scale operations on both lode and placer deposits. Jones[1] reports that placer mining was active in this district about 1884, prior to the discovery of the lode deposits.

The ores[2] occur as quartz veins in pre-Cambrian granite along and transverse to a fault contact between the granite and Tertiary volcanic rocks. They carry gold and silver in the ratio of about 1 to 8, and lead and zinc sulphides occur on the deeper levels.

PINOS ALTOS DISTRICT[3]

Pinos Altos is about 8 miles north-northeast of Silver City. The camp was originally named Birchville after its founder. Placer gold was discovered at this place in 1859 or 1860, and vein deposits were discovered a few months later. Mining was of short duration, owing to Indian depredations and to the Confederate invasion of the Territory, and was not resumed until 1867. A smelter was later built in Silver City to treat the Pinos Altos ore. Gold was originally the principal metal produced, but later silver, copper, lead and zinc became important products. In more recent years lead and zinc have ranked about equally with gold. From 1915 to 1919 the Empire Zinc Co. mined a large quantity of zinc-lead ore at the Cleveland mine and concentrated it in a magnetic-separation mill. Other producers in the past several decades include the Langston, Gillette, Calumet-New Mexico (Mogul-Grande), Houston-Thomas, Silver Cell, Jackson Consolidated, Manhattan, Pacific, Lead Hill, and U. S. properties. A number of mills have been operated in the district at various times. Placer mining was particularly active during the early history of the district, but placer mining on a small scale has been done practically every year since the boom period. The placers attracted increased attention in 1931.

[1] Jones, F. A., New Mexico mines and minerals, p. 63, 1904.

[2] Leach, A. A., The geology and history of the Malone mines: Ariz. Min. Jnl., vol. 12, No. 15, p. 5, 1928.

[3] Paige, Sidney, op. cit., pp. 14, 17.

Production prior to 1904 is said to have amounted to about \$4,700,000. From 1904 to 1929 the value of the production was \$3,328,608, making the total for the district over \$8,000,000. About 10 per cent of the value of the total production is accounted for by placer gold.

In the Pinos Altos district a mass of granodiorite intrudes a complex of diorite porphyry and associated dikes. Rhyolite and other lavas later than the veins cover the intrusive rocks on the north. West of the granodiorite mass, on the west side of the Pinos Altos Mountains, is an area of sedimentary rocks consisting of Pennsylvanian limestone and Cretaceous quartzite and shale.

Three classes of ore deposits occur in the district: (1) veins in the intrusive rock, (2) replacement bodies in the limestone, and (3) gold placer deposits. The veins form a northeast system which cuts both granodiorite and diorite porphyry masses. They are traceable for distances ranging from a few hundred to about 4,000 feet and die out at the ends by splitting into numerous branching veinlets. The average width is about 2½ feet. They are fissure fillings and contain chiefly pyrite, chalcopyrite, sphalerite, galena, gold and silver in a quartz gangue. Native silver, argentite and cerargyrite were the chief minerals of one important vein.

The replacement deposits in limestone are in the Magdalena limestone (Pennsylvanian) which is included in the Fierro limestone of earlier reports. There are two important ore bearing strata, 12 and 25 feet thick respectively, separated by 4 to 15 feet of limestone and cut by a number of dikes. The ore consists of an intimate intergrowth of sphalerite, galena, chalcopyrite, pyrite and quartz, and is chiefly valuable for its zinc content. Extensive oxidized ore bodies have been mined near the surface.

The important placer deposits are gulch or creek placers along Bear Creek, Rich Gulch, Whisky Gulch, and gulches near the old Gillette shaft. The gold is about 750 fine.

Production of Metals in the Pinos Altos District, Grant County, 1904-1929

	Gold		Silver, (Lode and Placer), ounces	Copper, pounds	Lead, pounds	Zinc, pounds	Total Value
	Lode	Placer					
1904	$ 49,660	$ 7,750	37,229	104,069	2,653	------	$ 92,438
1905	31,442	10,943	39,585	103,469	------	160,779	92,159
1906	89,674	2,290	83,566	328,788	------	------	212,245
1907	78,723	3,782	65,862	322,195	------	------	190,413
1908	8,548	1,479	8,941	34,514	3,953	------	19,488
1909	2,083	3,584	1,377	6,200	418	------	7,207
1910	1,372	2,494	223	269	2,226		4,119
1911	1,406	4,043	5,616	3,232	4,063	16,773	9,968
1912	7,973	2,551	15,864	96,507	50,289	929,176	102,581
1913	29,162	1,646	28,276	100,555	83,067	366,056	87,626
1914	114,181	21,560	23,256	129,587	29,994	48,840	169,497
1915	31,823	1,979	19,884	377,463	130,638	454,710	172,468
1916	11,775	2,009	17,816	122,716	152,696	6,741,925	969,649
1917	7,731	3,153	10,803	49,945	80,989	5,556,892	607,189
1918	1,972	672	2,243	12,227	40,028	3,013,802	285,005
1919	5,044	1,074	2,524	14,452	20,906	267,671	32,281
1920	3,168	554	2,000	2,456	40,325	43,247	13,083
1921	-----	2,368	37	-----	------	------	2,405
1922	19,142	2,079	55,820	26,193	673,847	------	117,639
1923	12,998	1,300	17,404	68,129	90,471	44,000	47,899
1924	2,164	1,042	1,979	4,320	62,135	------	10,069
1925	95	529	2,287	430	96,550	-----	10,672
1926	5,532	639	4,578	8,400	152,800	170,000	35,178
1927	5,332	693	4,591	12,206	142,492	130,000	27,524
1928	856	923	812	1,000	27,466	18,000	5,089
1929	1,760	491	2,180	4,557	8,047	------	4,722
Total 1904-1929	$523,606	$81,627	454,753	1,933,879	1,896,053	17,961,871	$3,328,608

SANTA RITA DISTRICT[1]

The Santa Rita district is in eastern Grant County. The town of Santa Rita is near the center of the district and about 12 miles east-northeast of Silver City. It is the terminus of a branch line of the Atchison, Topeka & Santa Fe railway leaving the Deming-Silver City branch at Whitewater.

The only copper mining of importance in the United States antedating operations at Santa Rita was at the native copper deposits of northern Michigan. Mining at Santa Rita by the Spaniards began in 1801, the copper being shipped to Chihuahua and Mexico City under contract to supply metal for Mexican coinage. Production during this early period is said to have amounted to 4,000,000 pounds of copper annually. It has been estimated that production up to 1904 amounted to 80,000,000 pounds. From 1904 to 1909, when the Santa Rita mines were purchased by the Chino Copper Co., annual production averaged 3,500,000 pounds of copper. Production dropped during the next two years, presumably because of preparations for steam shovel operations, which were started late in 1910. The first ore was milled a year later. From 1911 to 1930 inclusive, representing the period of steam shovel operation, production amounted to about 1,040,000,000 pounds of copper valued at approximately $180,000,000.

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[1] Paige, Sidney, op. cit., pp. 16-17.
Wells, E. H., Private report for the Chino Copper Co., 1924.
Thorne, H. A., Mining practice at the Chino mines, Nevada Consolidated Copper Co., Santa Rita, N. Mex.: U. S. Bur. Mines Inf. Cir. 6412, 1931.
Ballmer, G. J., Personal communications.

The following table shows annual production of metals in the Central mining district from 1904 to 1930. This includes production from the mines at Hanover, Fierro, Central and Bayard in addition to that from Santa Rita, since the figures for individual sub-districts cannot be segregated. Copper production as given in the table is almost entirely from Santa Rita.

Production of Metals in the Central District, Grant County, 1904-1930[a]

	Gold	Silver, ounces	Copper, pounds	Lead, pounds	Zinc, pounds	Total Value
1904	$ 5,582	282	3,264,208	11,977	------	$ 424,080
1905	------	8	3,179,206	------	96,424	501,650
1906	4	2,524	3,075,001	235,070	99,656	614,673
1907	5,659	36,813	4,994,575	855,358	73,729	1,078,555
1908	777	296	3,994,502	23,122	251,070	541,231
1909	816	1,380	3,348,808	23,256	203,278	448,856
1910	------	404	2,679,630	155	1,285,500	409,955
1911	104	8,673	1,413,189	605,978	290,122	225,156
1912	998	29,586	29,512,812	2,172,676	2,205,824	5,138,779
1913	9,697	12,500	51,695,656	331,440	2,187,266	8,167,144
1914	102,971	42,971	55,222,874	365,079	3,669,513	7,672,759
1915	102,379	73,267	66,581,366	1,542,234	5,628,870	12,561,729
1916	133,962	116,953	74,228,606	2,122,797	7,278,575	19,592,956
1917	138,873	121,386	82,200,421	2,250,337	7,398,853	23,627,822
1918	128,577	111,175	77,547,300	2,857,887	8,826,967	20,400,099
1919	57,280	34,508	40,358,634	1,283,642	4,299,658	7,984,543
1920	68,962	26,190	44,400,088	925,513	6,134,593	8,838,068
1921	10,439	9,688	9,138,442	4,422	95,000	1,203,935
1922	24,537	11,326	28,408,184	352,640	1,333,440	3,966,369
1923	68,108	29,264	54,374,770	1,311,141	13,017,000	9,062,131
1924	71,121	38,200	66,824,015	1,183,626	16,921,000	10,045,216
1925	97,299	76,547	68,812,280	2,363,260	15,033,000	11,269,879
1926	109,335	86,963	75,219,200	2,611,100	14,327,000	11,977,701
1927	98,963	85,963	66,971,008	1,907,476	10,076,000	9,685,941
1928	113,507	143,993	80,238,820	2,359,155	15,089,000	12,809,393
1929	131,631	374,398	87,445,648	7,532,318	22,448,000	17,677,723
1930	77,110	407,608	57,243,200	7,872,000	30,638,000	9,539,879
Total 1904-1930	$1,558,691	1,882,866	1,142,372,443	43,109,659	188,907,338	$215,466,222

[a] Includes Santa Rita, Hanover, Fierro, Central, and Bayard.

The ore reserves of the Chino mines amount to more than 100,000,000 tons averaging about 1.27 per cent copper, enough for about 35 years at the average rate of production prevailing under normal operating conditions. Prospecting for new ore is by means of churn drills, generally to a depth of about 900 feet.

The mines are now owned by the Nevada Consolidated Copper Co. Ore is treated at the company's mill at Hurley, 10 miles south of Santa Rita, to which it is hauled with standard railroad equipment. The mill has a capacity of 13,500 tons per day, and concentration is effected by flotation. The concentrate is shipped to the smelter of the American Smelting & Refining Co., at El Paso, Tex.

Santa Rita lies in a well-defined basin formed by a local widening of Santa Rita valley. The rim of the basin is highest at Santa Rita Mountain which has an elevation of 7,365 feet, about 1,600 feet above Santa Rita Creek. The mountain rises along a steep erosional escarpment 400 to 1,200 feet high and is cut by many steep gulches and canyons. A continuation of the escarpment forms the eastern rim of the basin. The remainder of the basin rim was originally formed by a series of hills rising 100 to

450 feet above the basin floor, but some of these hills have been removed, wholly or in part, by the steam shovels.

The rocks that crop out in the Santa Rita district consist of Pennsylvanian, Permian, Cretaceous and Tertiary sedimentary rocks, Cretaceous intrusive porphyries and Tertiary lavas and tuffs. The Pennsylvanian rocks are underlain by older Paleozoic and pre-Cambrian rocks which crop out to the north and east of the district.

The Pennsylvanian strata belong to the Magdalena formation and consist of limestone and shale in nearly equal amounts. The Magdalena formation, called the Upper Fierro limestone in earlier reports, ranges in thickness from about 600 to 825 feet in the vicinity of Santa Rita. A series of red beds, consisting chiefly of shales, crops out at several places in the district and has been tentatively correlated with the Abo formation of Permian age. It is definitely absent at most places, and its maximum thickness is about 200 feet. The Cretaceous sedimentary rocks are divided into the Comanchean Beartooth quartzite and the Benton (Lower Colorado) formation. The Beartooth quartzite consists chiefly of massive vitreous quartzite but contains also sandstone and shale. It is 40 to 135 feet thick. The Benton formation rests upon the Beartooth quartzite. It forms the present erosion surface over a large part of the district, and its full thickness is therefore not present. The maximum thickness exposed is about 585 feet. The formation consists essentially of sandstone and shale and includes a few limestone and calcareous layers. Shale predominates in the lower 175 to 225 feet of the formation. The Tertiary sedimentary rocks of the district consist of accumulations of tuffaceous gravels and sands interlain with volcanic tuffs. They were deposited upon an uneven erosion surface of Cretaceous and other rocks and are up to 400 feet thick in places.

The intrusive rocks at Santa Rita include sills, stocks and dikes. Most of the intrusives were injected probably in late Cretaceous time, but there are a few post-ore Tertiary dikes. The earliest intrusions were of quartz diorite porphyry and occur as sills and sill-like sheets. The largest of these is a great sill-like mass near the base of the Colorado formation, which contains numerous engulfed blocks and lenses of the sedimentary rocks. It is nearly 1,500 feet thick in places, but this great thickness is in part due to faulting. Smaller sills occur at other horizons in the Colorado formation and in the underlying rocks, and some of them are remarkably persistent.

The sedimentary rocks and the sills were intruded and domed by a large granodiorite porphyry stock, but the doming effect as a rule extends less than 1,000 feet from the stock. Satellitic dikes extend beyond the stock to the northwest and southeast, and a northeast trending system of granodiorite porphyry dikes cuts all the other pre-Tertiary rocks of the district.

Extensive erosion followed the period of intrusive activity and uncovered the intrusive rocks at several places. The Tertiary sedimentary rocks were deposited on the resulting surface. Explosive volcanic activity was current at this time and added considerable fragmental volcanic material to the sediments. Upon the Tertiary sediments was deposited a thick series of flow rocks which now form the main mass of Santa Rita Mountain. Rhyolite is dominant in the lower part of the series, but andesite prevails near the top. Several discontinuous layers of tuff are included in the flow series. The Tertiary rocks occur now only in the southern part of the district, though they doubtless covered all the area at some time.

The Santa Rita region is traversed by a complex network of faults. A northeast system is particularly prominent, but there are also a number of faults that strike in other directions. Faulting was operative over a considerable period of time, but the displacements are moderate as a rule. The earlier faults were intruded by some of the granodiorite dikes; the later ones have displaced the thick volcanic flows.

Igneous metamorphism of some of the sedimentary rocks is locally profound near the stock but as a general feature of the district is less pronounced than later hydrothermal alteration. Igneous metamorphism is present in some of the older igneous rocks also. Adjacent to the granodiorite stock and to some of the dikes the Magdalena limestone has been replaced by great volumes of iron oxides, garnet, epidote, chlorite and other silicates. The Colorado formation has been changed to a compact porcelain-like rock. Silicification and sericitization are pronounced features of all the rocks in the district and are particularly intense in the mineralized area. Large volumes of rock, both igneous and sedimentary, are so thoroughly changed that their identification is difficult or impossible.

Primary mineralization essentially followed the intrusion of the granodiorite dikes. Three types of deposits were formed: (1) contact-metamorphic deposits, (2) vein deposits, and (3) disseminated deposits in porphyry. The contact-metamorphic deposits are of little inherent economic importance and are mined only as encountered in the course of steam shovel operations on the disseminated ore. At and very near the surface of some of these deposits, where the sulphides have been completely oxidized, the remaining magnetite and hematite constitute potential iron ores. The vein deposits lie outside the immediate vicinity of Santa Rita and are discussed under the Central district. (See pages 51-52.) They generally consist of mixed sulphides in a quartz gangue.

The Santa Rita district owes its importance to the low-grade "disseminated porphyry" copper deposits. Primary mineralization of these deposits consisted of abundant pyrite, subordinate chalcopyrite and meager amounts of magnetite, specularite, molybdenite, pyrrhotite and sphalerite. The minerals were deposited along an intricate network of fractures and also were disseminated in the rock between the fractures. Most of the copper ore occurs in the granodiorite porphyry stock, but the quartz diorite south of the stock and the sedimentary rocks of the contact zone also are mineralized. Mineralization is more pronounced in the Magdalena limestone than in the other sedimentary rocks.

The material now mined as ore owes most of its value to secondary chalcocite enrichment. Chalcocite is the chief mineral of the sulphide ore. It occurs as disseminated particles, as larger solid masses and as small seams and stringers. Enrichment has shown a general preference for chalcopyrite over pyrite. The chalcocite zone extends for many hundred feet below the water table along major faults and other rock contacts where supergene circulation has been vigorous. Bodies of impervious rock practically free of enrichment have been found at several places adjacent to or over these deeper enriched zones. The Santa Rita ores carry much less silver and gold than is usual in ores of this type.

The thickness of the overlying oxidized zone is erratic. Here and there, in strongly fractured areas, tongues of oxidized ore extend several hundred feet below the water level. Elsewhere, the bottom of the oxidized zone lies some distance above this level. In general, copper carbonates and chrysocolla are most abundant in the upper part of the oxidized zone, cuprite in the middle part and native copper in the lower part. Native copper and copper oxides are exceptionally abundant, particularly along the more pronounced fractures. Native copper constituted a larger proportion of the ore at Santa Rita than at any of the other large similar deposits of the Southwest. The overlap of oxidized and chalcocite zones in which native copper and chalcocite are both abundant extends through a vertical distance of 100 feet or more.

The leached zone above the ore bodies is variable in thickness but generally shallow. It is absent in the northern part of the area but is about 150 feet thick in the southern part. It is usually much thicker in the igneous than in the sedimentary rocks and may extend to relatively great depths along strong fracture zones.

The ore body has not yet been completely delimited. In the main part it is at least 600 feet thick, but ore has been cut in some of the drill holes at depths of 1,000 to 1,600 feet. As at present known, the ore body forms a horseshoe-shaped mass around the granodiorite stock with a few isolated bodies at the open northwest side of the horseshoe. The width of the horseshoe band is irregular; it is 1,000 feet on the northeast, 2,000 feet on the southeast, 1,200 feet on the southwest and 400 feet on the northwest.

The leached zone over the ore is too small to have furnished the enriching copper for the secondary ores, and it is supposed by some that this copper came from overlying disseminated and probable contact deposits stripped away prior to the extrusion of the Tertiary lavas.

The ore of the Santa Rita deposits is somewhat richer than the disseminated ore in several other similar districts in the southwest. As in all deposits of this class, the line between ore and waste is an economic one controlled by the price of the metal and the cost of production.

SILVER CITY MANGANESE-IRON DISTRICT[1]

The Silver City manganese-iron district extends from Bear Mountain southeastward past Silver City to Lone Mountain and includes an area 15 miles long and 1 to 3 miles wide. The Silver City Range is a faulted monoclinal block of Paleozoic sediments underlain by pre-Cambrian rocks and intruded at a number of places by quartz monzonite porphyry.

Boston Hill, a low hill just southwest of Silver City, is the chief producing area of the district. The first mining at Boston Hill took place in the early seventies. The similarity of the ores to some of those found in the neighboring silver districts of Chloride Flat and Fleming Camp, which were active at the time, led to considerable prospecting for silver, but very little of this metal was obtained. Copper was found in the southern part of the hill but not in commercial quantities. The ores have been mined chiefly as manganiferous iron ores. A considerable quantity of fluxing ore was shipped to the smelters at El Paso, Tex., and Socorro, N. Mex., in the early nineties. Operations were continued to supply the Silver City smelter until this was closed down about 1903. Very little mining took place thereafter until it was vigorously resumed for a short while during the World War period. Activities since have been sporadic and relatively unimportant.

Boston Hill consists of Lower Paleozoic sediments and Cretaceous shales cut off on the east by a large mass of quartz monzonite porphyry. A large fault separates the shales from the Paleozoic rocks. A banded felsitic intrusion occurs in places along the contact between the porphyry and the limestone and forms sills in the limestone.

The manganiferous iron ores are divisible into three classes as follows:

(1) Irregular replacement bodies in El Paso, Fusselman and Montoya limestone. These deposits usually conform to the stratification but do not favor any particular beds. The larger ore bodies are commonly localized near fractures. Individual

[1] Wells, E. H., Manganese in New Mexico, op. cit., pp. 39-51.

bodies are commonly 6 to 12 feet thick, up to 50 feet or more in width, and up to 200 feet or more in length. The ore consists of a complex mixture of manganese and iron oxides and unreplaced limestone. Deposits of this class furnished the greatest production of the district.

(2) Replacement deposits in the banded felsite. The ore consists of the usual iron and manganese oxides and a notable amount of coarsely crystalline manganiferous ankerite.

(3) Fissure deposits. These deposits are of subordinate importance. The vein filling consists chiefly of manganese and iron oxides and small amounts of quartz and barite. Silver is also present.

It is estimated that the Boston Hill deposits have ore reserves[1] of several million tons. The ore mined contained 10 to 15 per cent of manganese, 30 to 38 per cent of iron, 7 to 10 per cent of silica, 0.01 per cent of phosphorus and 2 to 5 per cent of moisture.

In addition to the deposits at Boston Hill, there are a number of other deposits throughout the district. They are for the most part replacement deposits in limestone and have formed characteristically in the vicinity of fissures.

STEEPLE ROCK DISTRICT

The Steeple Rock district is in western Grant County, 4 miles from the Arizona line. The nearest railroad point is the town of Duncan, Ariz., about 17 miles southwest. The district was first prospected about 1880, and mining was carried on until about 1897. Production in this period is said to have amounted to about $3,000,000 in gold and silver. Since 1897 small lots of ore and bullion have been shipped from time to time.

The gold-silver ores of the district occur in veins in the Tertiary lava series. The veins, which are part of a complex system, are commonly marked by prominent siliceous outcrops. They carry quartz, calcite, pyrite, sphalerite, argentite (?) and galena, and contain free gold in some of the richer parts.

TELEGRAPH DISTRICT

The Telegraph district is on the Gila River about 20 miles west of Silver City. Silver ore was discovered in the district in 1881, but the deposit was soon exhausted. The latest reported shipment was a small lot of high-grade silver ore from the Bronx mine in 1920.

The district lies in an area of pre-Cambrian granite and gneiss. In places, remnants of sedimentary rocks are found which seem to be narrow blocks faulted into the granite. Both granite and sedimentary rocks are cut by porphyry dikes. The silver ore occurs in oxidized fluorite-bearing quartz-pyrite veins.

[1] U. S. Bur. Mines Mineral Resources. 1927, pt. 1. p. 193, 1930.

TYRONE DISTRICT

See Burro Mountain district, pages 48-50.

WHITE SIGNAL DISTRICT

The White Signal district is on the south side of the Big Burro Mountains about 8 miles south of Tyrone. The country rock is pre-Cambrian granite intruded by granodiorite porphyry. A number of quartz veins occur in the granite.[1] They are much oxidized but contain residuals of pyrite, chalcopyrite, galena, and locally also sphalerite. Bismuth minerals are present in small amounts. A fair gold content is said to have been found in places. Shipments of one or two cars of ore from these veins have been made nearly every year.

The White Signal district is notable chiefly because of the occurrence of the uranium minerals torbernite and autunite. The area in which these minerals have thus far been discovered covers approximately one square mile and is about a mile west of White Signal post office. The veins of this area were at one time worked for gold. Uranium minerals had been found in some of the veins but were confused with the green copper carbonate stain which is locally present. Their true nature was recognized in 1918 by Mrs. A. A. Leach. Considerable exploratory work was done on the veins, but according to Hess[2] "not enough torbernite could be found to make a valuable radium ore, even with hand picking."

The district has yielded a small amount of radium-uranium ore which has been used for immersion in drinking and bathing water and in the preparation of facial packs, toothpaste and salves.

The country rock in the vicinity of the uranium deposits consists of pre-Cambrian granite cut by a few felsite and pegmatite dikes and by numerous diabase dikes. Porphyry similar to the granodiorite porphyry of the Central district occurs near the west end of the area. Many of the diabase dikes are very narrow at the outcrop but widen considerably within a very short distance laterally and vertically. The uranium minerals occur in flakes in numerous small fractures and in small vugs; they seem to favor the thin decomposed edges of the diabase dikes, but equally good ore also occurs in the adjacent granite. Gouge and seams of talcy material are prominent locally and are commonly ore bearing.

Workings extend to a maximum depth of 150 feet, at which depth uranium minerals are said to persist. Pyrite is present in this vein from a depth of about 80 feet down.

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[1] Lindgren, Waldemar, Graton, L. C., and Gordon, C. H., The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, pp. 323-324, 1910.

[2] Hess, F. L., U. S. Geol. Survey Mineral Resources, 1920, pt. 1, p. 416, 1922.

GUADALUPE COUNTY

Guadalupe County occupies an area of 3,031 square miles in the east-central part of the State. There are no prominent mountains, and the rocks are almost entirely sedimentary.

Prior to the operations of I. J. Stauber in the Pastura district, Guadalupe County produced only 48 ounces of silver and 5,485 pounds of copper, the total value being $1,496. The first ore was shipped in 1916.

PASTURA (PINTADA) DISTRICT[1]

The principal copper deposits of the Pastura district are about 8 miles northeast of Pastura, a station on the Southern Pacific railroad. Although there are numerous prospects in the adjacent area, this place is the only one for which there seems to be a record of production. In 1925 extensive test drilling was carried on at the Stauber deposit, and mining operations were begun. Work was suspended in August, 1930, owing to the low price of copper. In the period from July, 1925, to August, 1930, the district produced 54,661 tons of ore containing approximately 5,000,000 pounds of copper, and valued at nearly $800,000.

The ore at the Stauber deposit occurs in the Santa Rosa (Triassic) sandstone and forms a flat-lying irregular body near the surface. It is about 1,500 feet long, 300 feet wide and 10 to 12 feet thick. The ore-bearing bed is a medium-grained gray sandstone whose cementing material has been replaced by ore minerals. The floor and roof of the ore-bearing bed are sharply defined. The floor consists of a hummocky bed of soft gray clay, and the roof is clay at some places but cross-bedded sandstone elsewhere.

The ore as mined averages about 4.8 per cent of copper and about 0.2 ounces of silver per ton. A 6-month composite sample assayed 1.7 per cent of zinc. Lower grade material occurs but is not commercial. It is estimated that about 96 per cent of the copper occurs as malachite and azurite, 3.5 per cent as sulphide, and most of the rest as chrysocolla. Bornite and chalcocite occur in the ore and are locally prominent in nodules which contain about 47 per cent of copper. A few logs replaced by copper sulphides have been found.

The ore owes much of its value to the fact that it is low in sulphur (0.3 per cent) and high in silica (80 per cent) and therefore desirable for certain smelter purposes.

HIDALGO COUNTY

Hidalgo County, separated from Grant County in July, 1920, is in the extreme southwest corner of New Mexico. It occupies an area of 3,447 square miles. This area is part of the Basin and

[1] Stauber, I. J., A sandstone copper deposit: Paper presented at El Paso meeting, West. Div., Am. Min. Cong., Oct., 1930.

Range province and is characterized by a number of sharply marked narrow ranges which trend north and south and are separated by wide, gently sloping arid valleys. The metalliferous deposits are scattered and differ widely in character. Copper, gold, silver and lead are the principal metals produced.

Production up to 1920 is included in statistics for Grant County. The accompanying table gives the annual production since 1920.

Production of Metals in Hidalgo County, 1920-1930[a]

	Gold	Silver, ounces	Copper, pounds	Lead, pounds	Total Value
1920	$ 153,659	202,477	2,786,114	211,274	$ 903,906
1921	23,628	65,693	582,140	160,423	171,636
1922	115,511	120,445	3,232,983	191,706	682,953
1923	216,924	149,783	4,337,238	223,957	992,997
1924	192,224	116,006	4,929,679	220,726	933,394
1925	222,823	136,568	5,076,140	468,200	1,079,146
1926	242,183	135,505	4,773,072	642,200	1,046,344
1927	197,401	92,896	4,078,588	232,159	798,994
1928	217,687	122,171	4,681,243	743,551	1,007,020
1929	219,528	170,244	4,285,114	1,047,715	1,130,454
1930	289,943	194,104	4,863,500	504,200	1,022,138
Total 1920-1930	$2,091,511	1,505,892	43,625,811	4,657,111	$9,768,982

[a] Prior to 1920 the production of Hidalgo County was included with Grant County.

APACHE NO. 2 (ANDERSON) DISTRICT[1]

The Apache No. 2 district lies at the southwestern base of the Apache Hills, a small group of rounded hills 6 miles south-southeast of Hachita. The mineralized area is said to extend into the Sierra Rica group of hills in Mexico. Annual shipments from this district during the past 15 years have been extremely small.

The Apache Hills[2] consist mainly of intrusive quartz porphyry overlain by Tertiary volcanic rocks to the north and in contact with Comanche and Magdalena (?) (Pennsylvanian) limestones to the south.

The ore deposits are oxidized contact-metamorphic deposits. They generally follow certain strata which have been recrystallized to coarse calcite. Some horn silver ore was shipped in the early days of the district, but the main product has been a low-grade oxidized copper ore containing gold and silver. Scheelite occurs in one of the deposits in considerable quantities, but none has been produced commercially. It is reported that bismuth has been recovered from some of the ore.

FREMONT DISTRICT

The Fremont district is about 15 miles southeast of Hachita in the northwestern foothills of the Sierra Rica. The junction

[1] This district is to be distinguished from Apache (Chloride) district in Sierra County.

[2] Darton, N. H., "Red Beds" and associated formations in New Mexico: U. S. Geol. Survey Bull. 794, p. 348, 1928.

of the Luna-Hidalgo County line and the international United States-Mexico boundary line lies within the district. Most of the mineralization is in Mexico.

The rocks of the region consist of Pennsylvanian and Cretaceous limestones[1] cut by intrusions of granite porphyry and lamprophyre. The ore deposits on the American side of the line occur in the limestone as replacement bodies and as quartz veins along faults. The replacement bodies are generally oxidized and carry oxidized copper, lead and zinc minerals intermixed with quartz and oxides of iron and manganese.

The quartz veins follow a northeast fault system. Iron and manganese oxides are prominent in the oxidized croppings, and both carbonate and sulphide ore minerals are present in the upper parts of the veins. The valuable minerals are argentiferous galena, chalcopyrite and locally a little gold.

HACHITA (EUREKA, SYLVANITE) DISTRICT

The Hachita district is in the Little Hatchet Mountains about 12 miles southwest of the town of Hachita and comprises the two smaller districts of Eureka and Sylvanite. The line between Hidalgo and Grant counties crosses the range between these two districts. The deposits of the Little Hachet Mountains are varied, but none has proved of any great economic importance.

The Hachita district was discovered about 1880. In 1908 a gold boom was started in the Sylvanite district, when placer gold was discovered in the course of work on some of the copper claims. The total metallic output of the district is probably between $500,000 and $750,000. A car of arsenic ore was shipped from the district in 1924. Production has continued in a small degree to the present time. Most of the placer production occurred during the boom period, but the total production from gravels is only about $2,750.

The Eureka district is at the northern end of the range. The deposits occur as veins and as bedded and irregular deposits in Paleozoic limestone and Cretaceous strata, and more rarely as veins in quartz monzonite porphyry. Minor intrusive porphyry masses are abundant, and the sedimentary rocks are locally metamorphosed. Argentiferous galena, zinc blende, pyrite, chalcopyrite, chalcocite and stibnite are the principal ore minerals. Wolframite is reported. The gangue is chiefly calcite and locally garnet.

The Sylvanite district adjoins the Eureka district to the south. The ores occur chiefly in quartz veins in a large mass of quartz monzonite cut by lamprophyre and syenite dikes, and also in the Magdalena limestone which adjoins the porphyry to the south. The ores near the surface carry free gold associated

[1] Darton, N. H., Idem.

with tetradymite in sericitic, limonite-stained quartz. Chalcopyrite and pyrite appear at a depth of about 30 feet. The district also contains a deposit of pyrrhotite and chalcopyrite replacing the cement in a quartzitic sandstone.

LORDSBURG (PYRAMID, VIRGINIA) DISTRICT

The United States Geological Survey and the State Bureau of Mines and Mineral Resources of the New Mexico School of Mines have arranged, under a co-operative agreement, for a geologic investigation of the Lordsburg mining district, particularly of the part known as the Virginia district. Several weeks in 1931 were spent by S. G. Lasky in examining part of the district, and mostly on underground work, as part of the investigation, and the following paragraphs are based in large part on information and material gathered at that time.

The Lordsburg district is in the northern part of the Pyramid Mountains, 3 to 10 miles southwest of Lordsburg, and includes two camps, Shakespeare or Virginia at the north end and Pyramid at the south. The principal mines of the district are owned by the Phelps Dodge Corp. and are at Valedon, 3 miles southeast of Lordsburg, in the Virginia district. Lordsburg is on the main line of the Southern Pacific railroad and on United States transcontinental automobile highway No. 80.

Prospecting in the Lordsburg district began in 1870. Silver was the metal chiefly sought, and rich silver ores were found in the Leidendorf (Venus, Viola) and Last Chance mines in the Pyramid district. Copper, lead and a little gold were also produced in the following years. A smelter was built in 1881 in the Virginia district and a stamp mill at the Leidendorf mine the following year, but neither operated for long. During the present century attention has been largely directed to mining for copper in the Virginia district, and the production of other metals, chiefly gold and silver, has been incidental. The district owes its importance as a copper producer chiefly to the operations of the Calumet & Arizona Mining Co. at the Eighty-five mine. In 1930 this mine produced at the average monthly rate of 800 oz. of gold, 8,600 oz. of silver and 390,000 pounds of copper.[1] It was acquired by the Phelps Dodge Corp. in 1931, and operations were suspended and the pumps drawn on Jan. 1, 1932. The Bonney mine has been the second and the Atwood (Alamo) mine probably the third largest producer. Both are copper mines in the Virginia district. Other well-known mines and prospects are the Nellie Bly and Robert E. Lee in the Pyramid area and the Anita, Misers Chest, Waldo and Aberdeen in the Virginia area. The copper deposits of the district are low grade but highly siliceous, and the large-scale operation of the mines was due largely to the need of siliceous fluxing ore at nearby smelters. Production to

[1] Youtz, Ralph B., Mining methods at the Eighty-five mine, Calumet and Arizona Mining Co., Valedon, N. Mex.: U. S. Bur. Mines Inf. Circ. 6413, 1931.

1904 from the entire district probably had a value of about $500,000 in silver, copper, lead and gold. Production from 1904 to 1930 amounted to $18,743,392, as noted in the accompanying table.

All rocks of the Lordsburg district are of igneous origin. They consist of basaltic andesite and subordinate associated volcanic rocks, probably Cretaceous, intruded by an irregular granodiorite stock of late Cretaceous or early Tertiary age. Tertiary volcanic tuffs, sands and breccias fringe the northern part of the area and are said to be predominant in the Pyramid district, particularly in the vicinity of the Last Chance mine at the south end. Quartz latite plugs cut the fragmental rocks. A large part of the Pyramid district is covered by Quaternary debris, and rock exposures are few.

Vein outcrops are prominent in the Virginia district, where they form bold, wall-like ledges locally called "siliceous dikes." They strike generally northeast and east, but members of the two sets join, cross, and change in strike from one set to another. In the Pyramid district vein outcrops are uncommon, owing to the gravel cover, and are inconspicuous. Nearly all veins dip steeply and are faults of small throw. Movement along them has been nearly horizontal. They have been cut and offset slightly by post-ore faults that strike at about right angles to the veins. Movement along the post-ore faults has been approximately along the dip.

The deposits of the Virginia and Pyramid sub-districts differ in character and presumably in origin. In the Virginia district they are the copper-tourmaline type of the deep vein zone, one of the few occurrences of this type in the United States. The veins are chiefly fissure fillings along shear zones which were repeatedly and spasmodically reopened during mineral deposition. Five periods of reopening have been identified, the latest movement being essentially contemporaneous with the post-ore faults. Each reopening was accompanied by a recognizable change in the material deposited. The resulting vein filling is commonly a highly vuggy and drusy mass in which mineral sequences are fairly clear. The veins are made up of typical shear linkages and sheeted zones which die out by progressive splitting at the ends. Branches, some of which rejoin the main vein, are common features, and at many places the ore occurs in overlapping veins or crosses along a linking fracture from one vein to a parallel one a few feet away, the main fractures continuing beyond the ore limits. Post-ore movement has occurred along all veins, almost invariably following the walls and forming thick masses of gouge and breccia along them.

Only one vein in the Virginia district, the Emerald vein of the Eighty-five mine, has been of notable economic importance. It has been traced on the surface for over 5,000 feet and has been mined from the surface continuously to a vertical depth of 1,900 feet and for an average of nearly 2,300 feet along the strike. Ore has been encountered in development work for an additional 300 feet of depth. These are the deepest workings in New Mexico. The productive part of the Emerald vein lies within the granodiorite stock, about 95 per cent of all ore mined having come from where granodiorite formed one or both walls. The vein is fairly regular and has an average width of about 5 feet. The grade of ore has been remarkably constant. The average of all ore shipped, including partly oxidized and secondary ores, has contained about 1.7 oz. of silver and 0.12 oz. of gold a ton and about 2.9 per cent of copper. The average primary ore contains about 1.23 oz. of silver and 0.11 oz. of gold a ton and 2.8 per cent of copper. The primary ore minerals consist of chalcopyrite and minor amounts of pyrite, sphalerite and galena. Sphalerite and galena are locally prominent. The gangue is predominantly drusy quartz. Calcite, some of it manganiferous, is conspicuous here and there, and small amounts of specularite, barite and tourmaline are present. Wall rock alteration consists of replacement by quartz, sericite and chlorite and impregnation by specularite and tufts of tourmaline. Depth of secondary alteration and the location of secondary and oxidized bodies are erratic. Secondary ores have been mined as deep as 1,500 feet below the outcrop, about 1,200 feet below the present water level. The secondary minerals are chiefly azurite, malachite and chalcocite and include also native copper, cuprite, chrysocolla, covellite and a little wulfenite.

In the Pyramid district to the south the veins contain partly oxidized silver ores and seem to be representative of the precious metal veins related to Tertiary lavas. They range in width from a few inches to several feet. The gangue consists largely of quartz, but includes much barite and the carbonates, rhodochrosite, siderite and calcite. Molybdenite has been reported.[1] Cerargyrite was the important ore mineral, and is said to have been accompanied by native silver and argentite. Tetrahedrite is said to have been the most important mineral in the Last Chance mine. Galena and chalcopyrite are sparingly distributed, and pyrite is rare. The ores are described as generally containing only a trace of gold and an insignificant amount of copper.

[1] Lindgren, Waldemar, Graton, L. C., and Gordon, C. H., The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, p. 333, 1910.

Production of Metals in the Lordsburg District, Hidalgo County, 1904-1930

	Gold	Silver, ounces	Copper, pounds	Lead, pounds	Total Value
1904	$ 1,208	2,580	18,200	12,000	$ 5,550
1905	10	7,584	48,000	-----	12,124
1906	5,168	27,261	212,601	-----	64,737
1907	8,761	31,303	463,335	10,522	122,646
1908	10,617	9,889	259,079	11,373	50,534
1909	25,983	50,154	589,969	8,862	129,140
1910	59,798	130,324	1,627,591	19,662	337,742
1911	106,648	182,448	2,455,336	2,157	510,859
1912	144,859	275,251	3,155,585	4,562	835,015
1913	55,234	154,779	1,601,461	14,572	397,588
1914	101,080	232,647	2,614,674	30,049	578,658
1915	222,848	374,325	3,890,365	28,723	1,094,795
1916	267,148	373,074	4,755,179	30,478	1,684,508
1917	245,607	295,443	4,261,956	41,442	1,656,180
1918	130,858	153,236	2,214,996	17,831	832,464
1919	175,008	242,733	3,516,457	58,264	1,103,758
1920	153,461	182,000	2,695,674	98,312	855,710
1921	22,987	35,119	579,295	13,134	133,426
1922	114,911	107,511	3,216,585	102,291	662,287
1923	216,554	141,538	4,314,122	46,185	970,024
1924	192,203	113,591	4,927,878	40,412	917,094
1925	222,823	126,781	5,064,140	69,700	1,035,981
1926	241,954	126,909	4,762,750	73,400	993,802
1927	197,333	77,155	3,933,496	46,381	750,290
1928	217,548	104,653	4,625,347	19,638	945,959
1929	219,359	159,163	4,248,193	59,080	1,055,597
1930	289,823	189,070	4,857,300	88,300	998,479
Total 1904-1930	$3,649,791	3,906,521	74,909,564	942,330	$18,743,392

RED HILL (GILLESPIE) DISTRICT[1]

The Red Hill district is in the Animas Mountains about 30 miles southwest of Hachita and 22 miles south of Playas. A small production was reported yearly from 1905 to 1913 and again for 1920 and subsequent years, though in each of these two periods the output came chiefly from a single mine. The country rock consists essentially of Tertiary volcanic rocks.[2] The ores are oxidized lead ores carrying also gold, silver and copper.[3]

STEINS PASS (KIMBALL) DISTRICT[4]

The Steins Pass district is in the northern extension of the Peloncillo Mountains. It lies close to the Arizona line just north of Steins Pass station on the Southern Pacific railroad. The district has been known since about 1875. Total production is valued at over $500,000.

The principal rocks of the district are rhyolite (?), diorite porphyry, and monzonite porphyry, the monzonite porphyry forming prominent dikes. Some faulting has taken place. The veins follow silicified brecciated zones in the country rock, and some of them may be traced for considerable distances. The quartz filling commonly shows a hackly or cellular structure.

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[1] Topog. map, Walnut Wells Quadrangle: U. S. Geol. Survey, 1923. Scale 1:62,500.
[2] Darton, N. H., Geologic map of New Mexico: U. S. Geol. Survey, 1928. Scale 1:500,000.
[3] U. S. Geol. Survey Mineral Resources, 1909, pt. 1, p. 438, 1911.
[4] Topog. map, San Simon Quadrangle: U. S. Geol. Survey, 1917. Scale 1:62,500.

Most of the ores are oxidized. Pyrite, chalcopyrite, galena, sphalerite, argentite, cerargyrite and native gold are present. Silver and gold are the principal metals.

SAN SIMON (GRANITE GAP) DISTRICT[1]

The San Simon district is situated on the western slope of the Peloncillo Range and extends from Steins Pass southward about 10 miles to Granite Gap. Work has been carried on in this district since 1880. Production probably has a value of about $750,000.

The ores occur chiefly as replacement bodies in unaltered limestone along or near porphyry dikes. The ore bodies are irregular and pockety. The ore is almost wholly oxidized and consists mainly of argentiferous cerusite and occasional residual kernels of galena. A little copper, zinc and arsenic are present, and also much limonite and manganese oxides. The ore as shipped contains from 10 to 15 ounces of silver a ton and up to 20 per cent of lead. Very little gold is present.

Some contact-metamorphic deposits occur in the district. The metamorphosed limestone is characterized by garnet, wollastonite and pyroxene. The ore minerals include pyrite, chalcopyrite, bornite and their oxidation products.

LINCOLN COUNTY

Lincoln County occupies an irregular area of 4,779 square miles in south-central New Mexico. The White, Jicarilla, Capitan and Gallinas mountains occupy the central and southern parts of the county. These mountains consist of monzonite porphyry intrusive into Paleozoic and Cretaceous sediments. The northern and eastern parts of the county are underlain chiefly by strata of the Chupadera (Permian) formation.

The principal mineral deposits are those of gold, and all occur in the mountain belt. Both lode and placer deposits have been worked. Production to 1930 is valued at between $3,000,000 and $4,000,000, most of which was prior to 1904.

[1] Idem.

Production of Metals in Lincoln County, 1904-1930

	Gold		Silver (Lode and Placer), ounces	Copper, pounds	Lead, pounds	Total Value
	Lode	Placer				
1904	$ 8,496	$20,100	2,576	-----	2,261	$ 30,183
1905	5,215	2,260	757	14,404	7,511	10,532
1906	16,463	-----	1,946	-----	-----	17,767
1907	41,417	-----	721	-----	-----	41,893
1908	28,896	816	5,472	1,195	-----	32,770
1909	23,391	472	388	700	7,977	24,499
1910	53,876	1,400	559	189	5,614	55,849
1911	30,305	1,629	184	555	6,620	32,399
1912	21,408	1,008	1,005	9,988	103,911	29,358
1913	41,469	1,027	1,100	7,068	94,010	48,392
1914	62,499	908	961	15,068	10,641	66,360
1915	44,068	1,308	493	5,091	13,277	47,141
1916	7,093	651	953	28,045	-----	15,270
1917	8,178	64	324	13,172	-----	12,105
1918	14,106	-----	177	1,850	-----	14,740
1919	11,146	-----	792	-----	-----	12,038
1920	4,110	-----	1,411	11,386	175,250	21,763
1921[a]	6,000	-----	1,200	49,240	155,222	20,537
1922	23,987	157	11,435	213,072	700,072	102,848
1923	9,112	137	3,102	38,966	232,657	33,807
1924	7,738	-----	442	8,596	26,912	11,313
1925	964	-----	141	2,500	-----	1,417
1926	-----	-----	-----	-----	-----	-----
1927	-----	-----	381	8,382	21,683	2,025
1928	-----	-----	253	1,118	10,535	920
1929	25	-----	1,606	391	1,000	1,013
1930	133	-----	179	700	12,900	938
Total 1904-1930	$470,095	$31,937	38,558	426,675	1,588,053	$687,872

[a] Estimated.

CAPITAN MOUNTAIN DISTRICT

Deposits of iron ore are reported[1] in the sedimentary rocks 30 miles east of Carrizozo, near the Capitan Mountains.

ESTEY (OSCURO) DISTRICT

Estey is 14 miles northwest of Oscuro, a station on the Southern Pacific railroad (formerly the El Paso & Southwestern railway). It lies at the southeastern edge of the Oscura Mountains, which extend southward from Socorro County. Although the presence of copper minerals had been known for many years, it was not until 1900 that an effort was made to mine the ore. The district has been idle for 20 years or more, and only a few carloads of ore have ever been shipped.

The ore occurs in the Abo "Red Beds" formation, which is repeated at the surface by a number of faults. Ore is found at three horizons, the most important of which is the arkose at the base of the "Red Beds." The copper-bearing layers are thin, for the most part a few inches to 3 feet thick. Ore also occurs in cross fractures and prominent joints. Malachite is the chief ore mineral. The sulphide ore consists chiefly of chalcocite which has replaced the calcite cement of arkose and sandstone. The chalcocite is very commonly associated with coaly matter in the arkose and occurs also in rounded nodules in limestone. The ores carry a minor amount of silver and a trace of gold. No gangue

[1] Min. & Sci. Press, vol. 119, p. 136, 1919.

minerals other than a small quantity of coal and other carbonaceous matter have been noted.

GALLINAS MOUNTAINS (RED CLOUD) DISTRICT

The Gallinas Mountains are about 10 miles west of Corona, a station on the Southern Pacific railroad. In the early days of the district ore was hauled by ox-team nearly 100 miles to the Socorro smelter. A small production has continued to the present time, but no production figures are available.

The Gallinas Mountains[1] are made up of a stock or sill of monzonite porphyry intrusive into Chupadera (Permian) limestone. To the south this mass tapers to a great dike which extends as far as Tecolote station.

The district contains deposits of silver, lead and copper, some of which are oxidized. The principal veins are said to be at the contact of the monzonite porphyry with the limestone. Deposits of iron ore are reported to occur along this contact near Elda.[2]

JICARILLA DISTRICT

The Jicarilla district is in the Jicarilla Mountains about 8 miles southeast of Ancho, a station on the Southern Pacific railroad. Certain streams of the district are said to have been worked for placer gold as early as 1850, but prospecting for lode deposits was not undertaken until the eighties. Only a small part of the placer deposits has been worked, and operations have been intermittent and on a small scale. They were resumed in 1931. Placer production probably has a value of $90,000 or more, but the production from the lodes has been trifling.

The gold-bearing gravels occur at numerous places in the district and were derived from degradation of nearby lode deposits. The gold is fine grained and angular, and some particles still adhere to bits of vein quartz. It has a fineness of about 920.

The gold lode deposits occur in the quartz monzonite porphyry that forms the main mass of the Jicarilla Mountains. The porphyry is traversed by many joints, and quartz and auriferous pyrite occur along the fracture planes. Some of the veins contain copper and silver in addition to gold. The lodes range in width from a few inches to over 40 feet. Water level and limit of oxidation are variable, and free gold occurs only where the pyrite has been oxidized. Some copper ore has been found in the limestone, and in places limestone has been replaced by pyrite which by oxidation has yielded high-grade iron ore near the surface.[3]

NOGAL DISTRICT

The Nogal district is rather indefinite in extent and is considered to include the sub-districts of Vera Cruz, Nogal, Parsons

[1] Darton, N. H., "Red Beds" and associated formations in N. Mex.: U. S. Geol. Survey Bull. 794, p. 215, 1928.
[2] Idem.
[3] Wells, E. H., Oral communication.

(Bonita), Schelerville (Church Mountain), Alto (Cedar Creek) and several isolated prospects within the same region.

The district lies mostly on the eastern side of the Sierra Blanca, which in this vicinity consists principally of monzonite porphyry. The monzonite is cut by dikes of finer-grained diorite porphyry, and andesite flows and tuffs occur locally.

Placer gold was found in the Nogal district as early as 1865. Lode claims were located in 1868, but active prospecting did not begin until 1882 when this region was withdrawn from the Mescalero Indian Reservation. Production of the entire district to 1910 has been valued at $250,000. Very little work has been done in the district since that date.

Most of the ore occurs in stringers and lodes in the porphyry and contains chiefly gold, pyrite and sphalerite in a gangue of quartz and dolomite. Galena and chalcopyrite occur sparingly. Gold ore also occurs in veins in the andesite which are almost free from sulphides other than pyrite, and in low-grade bodies in which the ore is simply altered porphyry. Several copper and lead-silver prospects have been worked in addition to the gold deposits.

WHITE OAKS DISTRICT

White Oaks is about 10 miles due northeast of Carrizozo, a division point on the Southern Pacific railroad. A small amount of placer gold was produced in the fifties and sixties, but the veins were not discovered until 1879. Mining was conducted with considerable vigor in the eighties and nineties, and several mills were erected. The Old Abe was the most important mine. Production to 1904 has been valued at $2,860,000. Production since that time has been small, and the value of all production to date probably does not greatly exceed $3,000,000. The Homestake stamp-amalgamation mill, treating ores from the North Homestake and South Homestake mines, produced a small amount of gold bullion nearly each year for many years prior to 1926.

The gold ore deposits are contained in fine-grained monzonite, which is intruded into Cretaceous shale. Both igneous and sedimentary rocks are cut by lamprophyre dikes. The deposits form narrow stringers and wider lodes which cut the monzonite, the dikes and the shale. They contain an unusual association of minerals. Albite, wolframite, hübnerite, tourmaline, fluorite and gypsum are present in addition to quartz, gold and auriferous pyrite.

The Old Abe vein was worked to a depth of about 1,400 feet, but the richest ore occurred near the surface in high-grade pockets and shoots. The average value of the ore milled in the district was about $18 to $20 a ton.

Deposits of iron ore have been reported in the district.

LUNA COUNTY

Luna County occupies a rectangular area of 2,976 square miles in southwestern New Mexico. It is bounded by Grant and Sierra counties on the north, Dona Ana County on the east, Mexico on the south and Grant and Hidalgo counties on the west.

The southern termination of the great Mimbres or Black Range lies in the north-central part of the county, nearly due north of Deming, and is known as Cooks Range. The rest of the county is topographically similar to Hidalgo County, though the mountain ranges are not so large nor so well marked and regular. The most prominent range in this part is the Florida Mountains southeast of Deming. Pre-Cambrian granite and Paleozoic sediments are the principal rocks in the main Florida Mountains and in the western part of the Mimbres Mountains, but most of the hills and mountains consist predominantly of Tertiary and Quaternary lavas.

Four important mining districts have been developed in the county, but in 1930 all but one were inactive. Lead ores have been mined at Cooks Peak, lead-silver-gold ores in the Victorio and Tres Hermanas Mountains and manganese in the Little Florida Mountains. Subordinate mineralization occurs in a few of the other hills. The Empire Smelting & Refining Co. operated a lead smelter at Deming for several years prior to 1917. The Peru Mining Co. constructed a custom selective flotation concentrating mill at Wemple near Deming in 1928, which operated until 1930.

The total value of the metals, exclusive of manganese and tungsten, produced in Luna County prior to 1931 was nearly $6,000,000. The production from 1904 to 1930 was $1,692,398.

Production of Metals in Luna County, 1904-1930

	Gold	Silver, ounces	Copper, pounds	Lead, pounds	Zinc, pounds	Total Value
1904	$ 1,695	8,549	16,000	671,772	------	$ 37,605
1905	-----	5,199	-----	463,956	225,000	38,221
1906	413	11,265	-----	831,193	103,836	61,673
1907	13,741	8,633	-----	1,022,773	------	54,207
1908	3	1,077	5,934	127,535	------	6,713
1909	3,208	6,916	1,115	682,906	------	36,314
1910	26	2,484	47	298,112	------	14,490
1911	104	1,278	1,814	98,888	------	5,458
1912	5,687	24,265	-----	827,556	458,594	89,493
1913	11,085	41,664	1,453	1,158,682	702,028	126,771
1914	226	2,975	2,181	416,923	793,588	58,694
1915	491	2,795	4,080	148,766	861,218	116,405
1916	3,535	18,077	2,663	868,724	2,725,582	441,255
1917	5,211	15,142	319	721,117	1,635,500	246,612
1918	8,214	16,442	3,150	490,493	463,445	102,432
1919	4,926	11,183	1,479	383,248	31,575	40,343
1920	6,671	11,611	3,864	359,488	21,098	50,506
1921	1,488	4,709	-----	144,467	------	12,698
1922	373	976	1,679	43,000	24,228	5,322
1923	1,300	2,312	1,041	85,472	------	9,332
1924	202	3,024	573	306,198	------	26,799
1925	980	6,603	2,500	595,020	119,300	66,751
1926	149	1,984	2,450	183,300	70,000	21,644
1927	325	2,058	367	206,080	------	14,523
1928	85	188	-----	9,000	------	717
1929	244	1,666	2,585	40,000	------	4,151
1930	306	904	500	51,000	------	3,269
Total 1904-1930	$70,688	213,979	55,794	11,235,669	8,234,992	$1,692,398

CARRIZALILLO HILLS[1]

The Carrizalillo Hills are in southwestern Luna County adjacent to the Mexican border. The extrusive rocks which compose these hills have been prospected at many points, and a small shipment of rich copper ore containing gold has been reported.

COOKS PEAK DISTRICT

The Cooks Peak district is on the north side of Cooks Peak and about 19 miles north of Deming. Ore was discovered about 1876, but the important mines were not located until 1880. The rich oxidized lead ores were particularly desired by the smelters, and the district displayed considerable activity for some time. Production up to 1904 has been valued at about $3,000,000 of which four-fifths represent lead and one-fifth silver. The district has been much less active since 1904 and was completely shut down in 1928. Production from 1904 to 1927 is valued at $896,901, making the total for the district somewhat less than $4,000,000.

Cooks Peak is a massive body of granodiorite porphyry, intrusive chiefly into lower Paleozoic limestones and shales but locally penetrating the Cretaceous beds. The ore deposits occur under broad arches in the upper silicified part of the Fusselman (Silurian) limestone—locally called Mimbres limestone—just below the Percha (Devonian) shale. They are characteristically

[1] Darton, N. H., Geology and underground waters of Luna County, New Mexico: U. S. Geol. Survey Bull. 618, pp. 106, 1916.

irregular in size, shape and distribution. The ores contain cerusite, smithsonite, limonite, galena, sphalerite and pyrite. The silver content is appreciable.

Silver ore has been mined in agglomerate on the east side of the range.[1]

COOKS RANGE MANGANESE DISTRICT[2]

The manganese deposits of the Cooks Range manganese district are at the southern end of the Cooks Range a few miles northeast of Mirage, a station on the Deming-Rincon branch of the Atchison, Topeka & Santa Fe railway. A small amount of ore was marketed during the World War.

The ore occurs in veins and replacement bodies in andesite, and as a cementing material of andesite breccia. Most of the ore consists of psilomelane. Manganiferous calcite is present in places, and fluorite was noted in one of the workings. Several tons of concentrate were obtained by treating the surface debris which contains a little psilomelane float.

FLORIDA MOUNTAINS DISTRICT[3]

The Florida Mountains are about 15 miles south-southeast of Deming. Many claims have been located in these mountains, but ore deposits of economic importance have been found on only a few. According to reports, the value of the ore produced in the district may be about $100,000.

The principal ores have been partly oxidized silver-bearing lead and zinc ores in limestone. Several small lodes of copper sulphides in shattered zones in granite have also been worked. Manganese outcrops are numerous in the limestone but as a rule are rather small. The manganese ore occurs for the most part as pockety replacement bodies in the limestone at several horizons.

LITTLE FLORIDA MOUNTAINS DISTRICT

The Little Florida Mountains is a small range just north of the main Florida Mountains and is composed chiefly of volcanic agglomerate. Important deposits of manganese have been developed and exploited in this district during recent years, during which period this district has furnished most of the manganese produced in New Mexico. Production since 1925 has amounted to approximately 13,000 tons of high-grade ore and concentrates. The important deposits have been operated by the Manganese Valley Mines (Inc.).

The manganese deposits occur in agglomerate on the east side of the range along a strongly brecciated zone which strikes about N. 11° W. and dips 60°-70° E. The ore occurs chiefly as fissure and breccia filling and subordinately as a replacement of the

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[1] Darton, N. H., op. cit., pp. 102-103.

[2] Wells, E. H., Manganese in New Mexico: N. Mex. Sch. of Mines, Min. Res. Survey Bull. No. 2, pp. 53-54, 1918.

[3] Wells, E. H., op. cit., pp. 54-55.
Darton, N. H., Geology and underground water of Luna County, New Mexico: U. S. Geol. Survey Bull. 618, pp. 107-108. 1916.

rock. Much of the ore itself is strongly brecciated and recemented by later material. The footwall of the vein is commonly solid and slickensided, but the hanging wall is brecciated and fractured for a considerable width. The ore is most abundant adjacent to the footwall as a massive band of manganese oxides that is separated from the wall itself by a foot or two of gouge or fine breccia. Toward the hanging wall the ore consists commonly of fissure and breccia filling and brecciated ore fragments. A number of parallel veins lie in the hanging wall, and ore occurs also along a number of cross fractures.

The average width of the vein is about 10 feet. The width ranges from about 5 to 60 feet and is widest at a place where the vein seems to split into two members. The principal minerals are pyrolusite, psilomelane and manganiferous calcite, and minute amounts of lead, zinc and silver occur in the ore. Rich manganese-oxide ores occur below as well as above the zone where calcite is abundant. Some of the ore consists essentially of psilomelane and coarsely crystalline white and black calcite. Locally the white and black calcite occur in adjacent bands. In the northern part of the district the ore in a number of minor parallel veins carries much barite and fluorite.

A large amount of drilling in the adjacent valley indicates that permanent water level is about 300 feet below the outcrop of the principal vein.[1]

The ore is roughly divided into two grades; direct shipping ore containing 40 to 50 per cent of manganese, and concentrating ore containing 20 to 40 per cent. Run-of-mine ore averages about 22 per cent of manganese. This yields a concentrate containing over 45 per cent of manganese, about 2.5 per cent of iron, 2.5 per cent of silica, and a trace of phosphorus.

Ore reserves in 1928, according to an estimate by R. H. West[2] who was operating the principal deposit, amounted to 100,000 tons of proved ore and 300,000 tons of probable ore containing 30 to 45 per cent of manganese, 1.5 to 3.5 per cent of iron, 0.02 per cent of phosphorus, 5 to 8 per cent of silica and 1.25 per cent of alumina. Additional development work was done in the interval between 1928 and the writer's visit in October, 1930.

FREMONT DISTRICT

This district is described under Hidalgo County.

TRES HERMANAS DISTRICT[3]

The Tres Hermanas Mountains are about 25 miles south of Deming and about 10 miles northwest of Columbus. The mineral deposits of the district have been known for many years. The value of the production of the district up to 1908 was possibly

[1] U. S. Bur. Mines Mineral Resources, 1927, pt. 1, pp. 190-192, 1930.
[2] U. S. Bur. Mines Mineral Resources, 1928, pt. 1, p. 217, 1931.
[3] Darton, N. H., Geology and underground water of Luna County, New Mexico: U. S. Geol. Survey Bull. 618, pp. 79-82, 105-106, 1916.

$200,000, chiefly in lead, gold and silver. Oxidized zinc ore was discovered in 1904, and some of this was shipped in 1905. The district has been inactive in recent years.

The Tres Hermanas Mountains consist largely of intrusive rocks flanked by small masses of Gym (Permian) limestone and later volcanic flows. Contact metamorphism is clearly evident. Garnet, diopside, and wollastonite are present in the metamorphosed sediments, and also the rare mineral, spurrite, which was identified in 1928 by A. H. Koschmann, professor of geology and mineralogy at the New Mexico School of Mines and geologist of the State Bureau of Mines and Mineral Resources.

The ore deposits consist of veins in rhyolite and intrusive porphyry and oxidized contact-metamorphic deposits in limestone. The veins carry ores of lead and gold. The contact-metamorphic deposits consist of oxidized ores of zinc containing lead and a little silver and occur in part interbedded in the limestone and in part in crosscutting veins. The zinc minerals include smithsonite, calamine, hydrozincite and the unusual anhydrous silicate willemite. Zincite is also reported.[1]

VICTORIO (GAGE) DISTRICT[2]

The Victorio Mountains are in west-central Luna County about 3 miles south of Gage, a station on the Southern Pacific railroad 19 miles west of Deming. The greatest activity in the district was from 1880 to 1886. Up to 1904 it produced oxidized argentiferous lead ores valued at $1,150,000. Almost the entire production came from only two mines, the Chance and the Jessie. Production has been small in recent years. From 1904 to 1929 the district produced gold, silver, lead, copper and zinc valued at $443,408.

The lead-silver-gold ores of the Victorio district occur in a detached limestone hill, known as Mine Hill, at the southeastern extremity of the Victorio Mountains. The main mass of these mountains consists of andesite and agglomerate flanked on the south by Paleozoic sediments. The rocks at Mine Hill are fine-grained dolomitic Montoya and Fusselman limestone. The ores occur in fairly distinct veins which are generally tight but which here and there widen abruptly into irregular bodies of galena in brecciated rock. The outcrops as a rule are inconspicuous. The ore is partly oxidized. The higher grade ores contain 15 to 22 per cent lead, and some ores carry as much as 50 ounces of silver and 2 ounces of gold to the ton. All the ores contain arsenic.

A quartz-wolframite vein cuts the Montoya limestone in the main ridge. The vein is 1 to 5 feet wide. Small amounts of pyrite, galena, wulfenite, scheelite (?) and a little gold are also present. It is reported that the tungsten ore grades into copper ore with depth.

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[1] Wade, W. R., Minerals of the Tres Hermanas district, New Mexico: Eng. and Min. Jour., vol. 96, pp. 589-590, 1913.

[2] Darton, N. H., op. cit., pp. 83-85, 103-104.

McKINLEY COUNTY

Aside from a few weak copper showings in the southeastern part, McKinley County is lacking in known metalliferous deposits.

MORA COUNTY

Mora County is in the northeastern part of New Mexico between Colfax County on the north and San Miguel County on the south. It has an area of 2,475 square miles.

The existence of small bodies of copper ore has long been known, but production seems to have been confined to the Coyote Creek district.

COYOTE CREEK DISTRICT[1]

The Coyote Creek district is northeast of Mora and includes the vicinities of Lucero and Guadalupita. Coyote Creek crosses the district from north to south. The copper deposits occur in carbonaceous shale of Cretaceous age. They were prospected and abandoned many years ago, but attention was again directed to them in more recent years. Two small mines made trial shipments in 1907, and 37 tons of ore was shipped in 1917 which yielded 6,315 pounds of copper valued at $1,724 and 40 ounces of silver valued at $33. Nothing appears to have been done since 1917.

OTERO COUNTY

Otero County is in central southern New Mexico. It is east of Dona Ana County and north of the State of Texas and covers 6,689 square miles. The western part of the county is covered by the sands of the Tularosa Valley out of which rise the Jarilla Hills. The Sacramento Mountains occupy the north-central part of the county and are continued northward by the Sierra Blanca.

Otero County has only three metal mining districts. Copper, gold and iron have been mined in the Jarilla or Orogrande district, copper from sandstone in the Tularosa district, and copper and lead from sandstone in the Sacramento Mountains. The Jarilla Hills have yielded most of the ore mined. The production of the county from 1904 to 1930 had a value of $1,683,105.

[1] Austin, W. L., Some New Mexico copper deposits: Proc. Colo. Sci. Soc., vol. 6, pp. 91-95, 1897.

Production of Metals in Otero County, 1904-1930

	Gold		Silver, ounces	Copper, pounds	Lead, pounds	Total Value
	Lode	Placer				
1904	$ 1,569	$ 1,050	164	14,400	------	$ 4,586
1905	41	1,036	93	53,602	------	9,495
1906	228	195	583	133,166	------	26,481
1907	14,711	100	2,135	679,480	------	152,116
1908	35,215	1,475	4,351	723,907	------	138,552
1909	157	100	29	6,354	------	1,098
1910	2,559	8,581	2,046	49,874	6,046	16,286
1911	6,718	-----	715	22,730	739	9,971
1912	11,005	2,034	1,107	146,588	------	87,907
1913	49,830	42	7,088	760,914	1,911	172,179
1914	38,515	-----	5,761	418,316	2,027	97,416
1915	54,979	-----	6,255	872,748	------	210,881
1916	39,525	805	7,928	1,166,972	17,392	333,321
1917	23,510	737	4,850	814,736	13,907	251,862
1918	5,096	-----	2,142	264,417	------	72,549
1919	74	-----	25	4,382	------	917
1920	-----	-----	-----	------	------	------
1921	5,230	-----	32	------	------	5,263
1922	-----	-----	-----	------	------	------
1923	366	-----	345	5,435	195,943	15,164
1924	21	-----	397	4,046	129,286	11,160
1925	715	-----	104	14,900	82,000	10,037
1926	-----	-----	-----	------	------	------
1927	396	-----	127	11,923	72,126	6,574
1928	4,104	-----	858	80,243	287,000	32,807
1929	7,865	-----	1,730	155,489	267,000	52,474
1930	405	-----	426	32,000	285,600	19,009
Total 1904-1930	$302,334	$15,655	49,241	6,436,622	1,360,977	$1,683,105

OROGRANDE (JARILLA, SILVER HILL, BRICE) DISTRICT

Orogrande is a station on the Southern Pacific railroad in southwestern Otero County. The Jarilla Hills are a few miles northwest of Orogrande.

Prospecting was first conducted in the Jarilla Hills in 1879, but no real mining was done until about 20 years later. A 250-ton matting furnace was operated at Orogrande from 1907 to 1909. Iron ore was shipped to Pueblo, Colo., intermittently from 1916 to 1921. The iron ores were produced chiefly from the Cinco de Mayo, Iron Duke, Lincoln, Seven-Come-Eleven and Three Bears claims. A jigging plant for treating these ores was operated during 1921. Up to about 1904 the district yielded approximately $100,000 in gold and copper. Of this amount about $8,000 came from dry placer operations. From 1904 to 1929 the district produced gold, silver, copper and lead to the value of $1,446,491, of which over $13,000 represents placer gold. No figures on the value of iron ore production are available. The district has also produced a little tungsten ore.[1]

The Jarilla Hills consist of an irregular mass of fine-grained monzonite porphyry, which has intruded Carboniferous limestone. The limestone is metamorphosed near the contact and contains iron oxides and typical contact silicates. The ores occur as contact-metamorphic deposits in the limestone and follow

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[1] Finlay, J. R., Report of appraisal of mining properties of New Mexico: N. Mex. State Tax Com., p. 82, 1922.
U. S. Geol. Survey Mineral Resources, 1920, pt. 1, p. 559.

bedding planes and fracture zones across the strata. They contain pyrite, chalcopyrite and associated gold and silver. Some of the deposits in the metamorphic rock are essentially quartz-pyrite veins having indefinite boundaries. The ores are partly oxidized.

Placer deposits, the gold of which was derived from some of the lode deposits, have been worked on the southeastern slope of the hills. The gravels are reported to assay about $1 a cubic yard. Water is very scarce, and most of the gold has been recovered with some form of dry washer. The gold is about 940 fine.

SACRAMENTO (HIGH ROLLS) DISTRICT

The Sacramento district is in the Sacramento Mountains east of Alamogordo and includes an area about 6 miles long between Alamo Canyon and High Rolls, a station on the Cloudcroft branch of the Southern Pacific railroad. The shipping point is La Luz, 8 miles northwest of High Rolls and 5 miles north of Alamogordo. It is estimated that about 1,600,000 pounds of lead and 100,000 pounds of copper were produced to Jan. 1, 1932. Most of the recent production has come from the Stewart and Holmes property.

The ores occur chiefly as disseminations of chalcocite and galena in Abo (Permian) arkosic sandstone and grit. Minute amounts of chalcopyrite and bornite are present locally. Copper carbonates and nodules of chalcocite occur in some of the interbedded shales. In places the sulphides have completely replaced the cement of the rock, and the ore consists of grains of quartz and feldspar in a matrix of chalcocite or galena. Carbonaceous matter is scarce and bears no obvious relationship to the sulphides. The lead and copper ores occur in separate bodies. Both classes of ore are said to contain about 8 per cent of the respective metal. The silver content is very low. A siskin to olive-green amorphous material that seems to be cuprodescloizite (psittacinite), a copper-lead vanadate, occurs as thin coatings along the fractures of the rock associated with the lead ore.

TULAROSA (BENT) DISTRICT

The Tularosa district is near the southwestern base of the Sierra Blanca. The mines are in the vicinity of Bent, a camp about 10 miles northeast of Tularosa. Development of these mines began in 1904, and operations were essentially continuous until about 1917. No production figures are available.

The country rock of the Tularosa district consists of Pennsylvanian and Permian sediments which near the mines have been arched by a mass of diorite porphyry.

The ores occur as disseminated particles in sandstone and in veins in the diorite porphyry and limestone. According to Darton,[1] the camp of Bent is situated in an area of Chupadera lime-

[1] Geologic Map of N. Mex., op. cit.

stone and therefore the deposits presumably occur in the sandy beds of this formation.

The ores in sandstone are similar in appearance to the general "Red Beds" type. Malachite, azurite and chalcocite are disseminated through certain parts of the rock and along minor cross fractures. Scattered grains of pyrite and chalcopyrite are present. The ores are not far distant from the diorite porphyry outcrop.

The diorite porphyry and limestone are cut by veinlets and stringers of quartz, dolomite and barite that carry a moderate amount of chalcocite and very subordinate pyrite and chalcopyrite. A little chalcocite is disseminated in the porphyry between the stringers. A black resinous hydrocarbon is intergrown with the vein minerals and occurs also in limestone wallrock. The ores contain some silver and a little gold in addition to the copper.

QUAY COUNTY

Quay County is at the eastern edge of New Mexico. Copper mineralization has been reported in the Triassic shales and sandstones near Logan.

RIO ARRIBA COUNTY

Rio Arriba County is in northern New Mexico west of Taos County. The State of Colorado adjoins it to the north. The county occupies 5,871 square miles.

The western half of the county belongs to the Plateau province and is underlain by flat-lying sedimentary rocks of Tertiary and Cretaceous age, which contain valuable coal beds. The eastern half lies in the Rocky Mountain province, and in this part rocks ranging from pre-Cambrian to Tertiary in age are exposed. Metalliferous deposits are confined to this part of the county. Gold and copper are the principal metals. From 1904 to 1929 the county produced metals having a value of $37,479.

ABIQUIU DISTRICT

Abiquiu is about 16 miles northwest of Alcalde on the Denver & Rio Grande Western railroad. The deposits of the district, all of which are rather unimportant, are chiefly of the typical "Red Beds" copper type.

BROMIDE (HEADSTONE) DISTRICT

The Bromide district is just south of Tusas, which is about 9 miles west-northwest of Tres Piedras, a station on the Denver & Rio Grande Western railroad. Ore was discovered in 1881. The district was never very important. Approximately $30,000 may represent the total value of production, which was principally in copper.

The ore deposits occur in pre-Cambrian amphibolite schist and are believed to be of pre-Cambrian age. They consist of lenticular quartz-pyrite veins and impregnations of sulphides along certain zones in the schist. The sulphides consist chiefly of auriferous pyrite and chalcopyrite. Galena, sphalerite, tetrahedrite, molybdenite, magnetite and specularite are present locally. Garnet, epidote, hornblende and tourmaline occur in the wall-rock. The deposits generally have a low gold content, but a few contain a moderate amount of silver.

EL RITO PLACER DISTRICT[1]

The so-called El Rito district is north of the town of El Rito in the Chama Basin and largely between El Rito Creek and Arroyo Seco.

The gold-bearing rocks of the district consist of conglomerate and minor sandstone beds of the Santa Fe (Tertiary) formation. The series attains a maximum thickness of at least 1,000 feet and is hundreds of feet thick over much of the El Rito area. The conglomerate is well cemented, and much of it is colored red by iron oxides. Gold is sparingly distributed through parts of the conglomerate, commonly in the fine-grained matrix. The rock contains only about 10 cents a ton in gold and a trace of silver and is so well cemented that blasting and crushing would be required. The deposit offers no possibilities for commercial mining.

GALLINA DISTRICT

The Gallina district includes a number of non-productive prospects which occur in a large area of indefinite limits in the vicinity of Gallina, a village near the north end of the Nacimiento Mountains. The copper deposits occur in micaceous sandstone and conglomeratic grit of Permian[2] and Triassic age. The ores consist principally of copper carbonates scattered sporadically through the rock in impure bodies, thin sheets and stringers. A few thin seams of bornite are present. Plant remains occur in small amount but have no intimate association with the ore. Barite is present locally.

A shipment of lead ore has been reported[3] from this district, and a shipment of copper-silver lode ore[4] from near Jarossa, at the southern end of the district.

HOPEWELL (HEADSTONE) DISTRICT

The Hopewell district is a westward extension of the Bromide district. The ore deposits of the two districts are similar in most respects. The principal difference is in the kind and relative amounts of metals present. In the Hopewell district gold is

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[1] Wells, E. H. and Wootton, T. P., Gold mining and gold deposits in New Mexico: N. Mex. Sch. of Mines, State Bur. of Mines and Min. Res. Circular 5, p. 15, 1932.

[2] Darton, N. H., "Red Beds" and associated formations in New Mexico: U. S. Geol. Survey Bull. 794, Pl. 37, 1928.

[3] U. S. Geol. Survey Mineral Resources, 1908, pt. 1, p. 517, 1909.

[4] U. S. Geol. Survey Mineral Resources, 1916, pt. 1, p. 206, 1919.

the chief metal produced, and copper and silver are subordinate. Pyrite is more abundant and chalcopyrite less so than in the Bromide district, and some native gold has been found in the oxidized ores. The ores range widely in value.

A deposit of iron ore, consisting mostly of magnetite, has been opened in the pre-Cambrian schist, and rich gold placer deposits have been worked in the western part of the district. The district first received attention through the discovery of these placers which are said to have yielded $175,000 in the first three years. The value of the total output of the district is probably about $300,000.

NACIMIENTO DISTRICT

See Sandoval County.

PETACA DISTRICT[1]

Petaca is 12 miles north of La Madera station on the Denver & Rio Grande Western railroad. The rocks of the district are pre-Cambrian quartz-mica schists, which enclose a group of pegmatite dikes. Radio-active minerals are present in the pegmatites. A shipment of several hundred pounds of columbite was made in 1931.

RINCONADA DISTRICT

The Rinconada district may be considered the extreme western tip of the Picuris district, Taos County. Wolframite associated with tourmaline, quartz and copper minerals occurs in a pegmatitic vein near Rinconada.[2] Cuprotungstite (?) occurs with some of the wolframite.[3]

SANDOVAL COUNTY

Sandoval County covers an area of 3,871 square miles in north-central New Mexico. Bernalillo County lies to the south and Rio Arriba County to the north.

The metalliferous deposits occur in the central and eastern parts of the county, chiefly in the Nacimiento and Valle Mountains. The Nacimiento Range is an overthrust block[4] about 30 miles long in the central part of the county extending northward into Rio Arriba County. Pre-Cambrian granite is exposed on its steep western scarp. The Valle Mountains are in the northeastern part of the county and are of volcanic origin.

Production from this county has been unimportant in recent years. The total output from 1904 to 1929 is valued at only $130,659. Ores of copper, gold, silver and lead have been produced.

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[1] Hess, F. L., and Wells, R. C., Samarskite from Petaca, New Mexico: Am. Jnl. Sci., 5th ser., vol. 19, pp. 17-26, 1930.

[2] Hess, F. L., Tungsten minerals and deposits: U. S. Geol. Survey Bull. 652, p. 38, 1917.

[3] Idem, p. 33.

[4] Renick, B. C., Geology and ground-water resources of western Sandoval County, New Mexico: U. S. Geol. Survey Water-Supply Paper 620, pp. 71-74 and Pl. 2, 1931.

COCHITI (BLAND) DISTRICT

The Cochiti district is in the southern foothills of the Valle Mountains. The town of Bland, the principal camp of the district, is about 30 miles west-northwest of Santa Fe. Production from this district began in 1894 and to the close of 1904 amounted to slightly over $1,000,000 in value. A mill was constructed and operated during parts of 1914, 1915 and 1916, but with the exception of this short period hardly more than occasional assessment work has been done since 1904.

The principal rocks of the Cochiti district are rhyolite flows. Underlying monzonite is exposed in a canyon in the vicinity of Bland. The ores seem to be confined to the monzonite and nowhere are known to extend into the overlying rhyolite. The ore bodies consist of quartz veins and lodes in a complex system of fractures in shattered and brecciated zones. The ore occurs as open space filling and as replacement of the walls. Replacement ore extends rarely more than 10 feet from the open channel and is poorer than the channel filling. Some of the ore shoots are very wide, though low grade. The metal content of the ore shoots is said to decrease gradually in depth until the vein becomes economically valueless, the deepest ore of the district giving out at a depth of about 600 feet. Small rich pockets are common.

The principal metals recovered are gold and silver, and finely divided argentite is the principal ore mineral. Sphalerite and pyrite are the most abundant sulphides, though they constitute but a small fraction of the vein matter. Chalcopyrite and galena occur sparingly.

Oxides of vanadium and uranium are reported filling interstices in a silicified volcanic breccia at one place.

JEMEZ SPRINGS DISTRICT[1]

Jemez Springs lies in the valley between the Nacimiento and Valle Mountains and is about 15 miles west-northwest of Bland in the Cochiti district. Siliceous sulphide ore containing copper, silver and gold occurs nearby. The district is not very old. The latest shipment consisted of several cars of copper-silver ore sent to El Paso, Tex., in 1929.

NACIMIENTO MOUNTAINS (CUBA) DISTRICT

The copper deposits of the Nacimiento Mountains occur in Permian[2] and Triassic "Red Beds" which consist of sandstone, marl, conglomerate and shale. The principal ore mineral is chalcocite, but considerable bornite, azurite, malachite and chrysocolla are present. Some of the ore minerals are finely disseminated through the rocks, but generally they are associated with

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[1] Darton, N. H., op. cit., (U. S. Geol. Survey Bull. 794), pp. 158-167, and Pl. 37.
U. S. Bur. Mines Mineral Resources, 1926, pt. 1, p. 726, 1929; idem, 1927, p. 472, 1930; idem, 1928, p. 553, 1931.

[2] Darton, N. H., Idem.

wood and plant remains which they have wholly or partly replaced.

These deposits were originally located by Indians and Mexicans about the middle of the last century. An effort at systematic mining was first made in 1880. All ore produced was smelted locally. Production amounts to about 5,250,000 pounds of copper valued at about $625,000. The district has been practically idle for many years.

PLACITAS DISTRICT[1]

The Placitas district is at the north end of the Sandia Mountains and geologically constitutes an extension of the Tijeras Canyon district of Bernalillo County. The district is in the prospect stage.

In addition to lode deposits of copper, lead and silver, gold placer deposits in partly cemented gravel have been worked in the Placitas-Tejon region at the north end of the Sandia Mountains.

SAN MIGUEL COUNTY

San Miguel County covers an irregular area of 4,894 square miles in northeastern New Mexico, east of Santa Fe County. The northwestern part of the county, in which pre-Cambrian, Pennsylvanian and Permian rocks are exposed, lies in the Rocky Mountain province. The rest of the county lies in the Great Plains province and is covered chiefly by Triassic and Cretaceous strata.

Mineral deposits are few and are confined to the mountain area. Most of them are of pre-Cambrian age. The deposit of the Pecos mine of the American Metal Co. of New Mexico at Willow Creek is one of the most important in the State. Its output essentially represents the production of San Miguel County. The value of the total production from 1927 to 1930 was $15,941,673. Production from the county prior to 1927 was negligible.

EL PORVENIR (HERMIT MOUNTAIN) DISTRICT[2]

A deposit of molybdenite in a pegmatitic gangue of quartz, feldspar and fluorite has been opened up in pre-Cambrian rocks[3] near El Porvenir, 14 miles northwest of Las Vegas. The molybdenite occurs in small scattered pockets and is closely associated with chalcopyrite. Other associated minerals are scheelite, bismuthinite, molybdite and malachite.

ROCIADA DISTRICT

Rociada is in northwestern San Miguel County, about half a mile south of the Mora County line. The town was formerly

[1] Ellis, R. W., Geology of the Sandia Mountains: Univ. of N. Mex. Bull. 108, pp. 40-42, 1922.

[2] Horton, F. W., Molybdenum; its ores and their concentration: U. S. Bur. Mines Bull. 111, pp. 78-79, 1916.

[3] Darton, N. H., Geologic map of New Mexico: U. S. Geol. Survey, 1928. Scale 1:500,000.

known as Rincon. Mineral deposits are said to have been discovered about 1900, but only a small amount of work has been done.

Most of the deposits are of pre-Cambrian age and consist of fissure veins in the ancient gneisses and schists. Some disseminated copper carbonates accompanied by a little chalcocite occur locally in the basal Carboniferous grit. The pre-Cambrian quartz veins contain gold, silver and various copper, lead and zinc minerals, and are generally parallel to the foliation of the country rock. The wall rock is commonly altered, and contact metamorphic minerals occur locally.

TECOLOTE DISTRICT

The Tecolote district occupies a considerable portion of western San Miguel County and includes the Tecolote (Las Vegas), Salitre, San Pablo, Mineral Hill[1] and San Miguel camps or subdistricts, all of which lie west and southwest of Tecolote Mountain, a prominent butte 6 miles southwest of Las Vegas. Attempts at mining were made about 1900, and about 5,000 pounds of cement copper was produced during trial runs at a local leaching plant.

The surface rocks of the district are strata of Permian and Pennsylvanian age under which are pre-Cambrian gneisses and schists. The mineral deposits consist of copper minerals disseminated through certain beds. The copper minerals are chalcocite, bornite, chalcopyrite and their oxidation products, malachite and azurite. The sulphides have replaced the carbonate cement of arkosic sandstone, and also to some extent the kaolinized feldspar grains. In some places the copper is fairly evenly distributed throughout the rock, but elsewhere it is largely confined to narrow bands parallel to the bedding.

WILLOW CREEK (PECOS, COOPER) DISTRICT[2]

The importance of the Willow Creek district is entirely due to the operations of the American Metal Co. of New Mexico at the Pecos mine, one of the most important mines in the State. The mine is at Tererro in the canyon of the upper Pecos River at its junction with Willow Creek and is about 3 miles from the Santa Fe-San Miguel County line. Glorieta, on the main line of the Atchison, Topeka & Santa Fe railway, is the nearest railroad point and is 14 miles south-southwest of the mine. The concentrating plant is at Alamitos, about 5 miles from Glorieta.

The Pecos mine, formerly known as the Hamilton or Cowles mine of the Pecos River Mining Co., was first located about 1882. Development work was intermittent until the property was acquired by the Goodrich-Lockhart Co. in 1916. This company car-

[1] Jones, F. A., New Mexico mines and minerals, pp. 197-198, 1904.

[2] Matson, J. T., and Hoag, C., Mining practice at the Pecos mine of the American Metal Co. of New Mexico: U. S. Bur. Mines Inf. Circ. 6368, 1930.
Stott, C. E., Geology of the Pecos mine; Eng. and Min. Jnl., vol. 131, pp. 270-275, 1931.
See also Krieger, Philip, Geology of the zinc-lead deposit at Pecos, New Mexico: Ec. Geol., vol. 27, pp. 344-364, 450-470, 1932.

ried on an intensive diamond-drilling and development program until 1925, in which year the mine was taken over by the American Metal Co. who began preparations for large-scale production. Much underground work was done and a 600-ton selective flotation mill was built. Milling operations started in January, 1927, and since then the mine has been the largest individual producer of gold, silver, lead and zinc in New Mexico. Up to January, 1930, there had been mined and milled 584,158 tons of ore averaging 0.109 oz. of gold and 3.39 oz. of silver to the ton, and 16.06 per cent of zinc, 3.73 per cent of lead and 1.02 per cent of copper. The lead concentrate is shipped to El Paso, Tex., and the zinc concentrate to Blackwell, Okla., and Langeloth, Pa. Because of the complex character of the ore, very little was shipped prior to the milling operations of the American Metal Co.

The ore deposits of the Pecos mine occur in pre-Cambrian rocks. In the vicinity of the mine these rocks crop out only in a small area where the Pecos River and its tributaries have cut through the overlying limestone and shale of the Magdalena formation. At only a few places do the ore bodies reach the overlying sedimentary rocks and nowhere do they extend into them. The pre-Cambrian rocks in this part of New Mexico are largely granite, but at the Pecos mine blocks of older diabase occur. Both rocks have been strongly sheared, and the rocks along the shear zones have been converted to schist. The diabase is metamorphosed to chlorite and garnetiferous amphibolite schists and the granite to quartz-sericite schist. Diabase, granite and schists are cut by pegmatite dikes. The main shear zone has an average strike of N. 40° E. It dips 70°-80°NW. in the upper 500 feet of the mine but southeastward on the lower levels. It is about 600 feet wide at the widest part but narrows and almost disappears to the northeast.

The ore fills openings in the schistose rock and replaces the schist in the northeast part of the main shear zone. Two ore bodies have been developed in this zone, each of which consists of a series of irregular, disconnected, locally overlapping lenses. Individual pods or lenses of ore are as much as 30 or 40 feet thick. Post-ore shearing is shown by one of the ore bodies in which slices of ore have been crushed and displaced. The two ore bodies seem to converge to the northeast and have been followed for an aggregate length of 2,000 feet and from the surface to the 1,200-foot level. Drilling has shown that one of them extends for a considerable distance below the lowest level. The ore bodies rake 30°-50° SW.

The ore consists essentially of an intimate mixture of sphalerite, pyrite and subordinate argentiferous galena. Chalcopyrite is scattered throughout the ore and in many places is associated with stringers of white quartz. Minor quantities of pyrrhotite, tetrahedrite, bornite, argentite and proustite have been identified. The ore has an appreciable content of gold and silver. Gangue consists of quartz, tourmaline, minerals of the schists and a little fluorite. The depth of oxidation is shallow. Secondary chalcocite enrichment has been negligible, and only small quantities of lead, zinc and copper oxidation products have been found.

Production of Metals from the Willow Creek District, San Miguel County, 1927-1930

	Gold	Silver, ounces	Copper, pounds	Lead, pounds	Zinc, pounds	Total Value
1927	$ 235,766	509,446	1,989,000	8,706,000	42,445,000	$ 4,050,139
1928	309,697	495,930	2,120,000	10,385,000	46,410,000	4,338,436
1929	343,064	471,619	2,641,000	11,439,000	45,730,000	4,798,090
1930	271,127	406,865	1,438,000	10,861,000	33,276,000	2,755,008
Total 1927-1930	$1,159,654	1,883,860	8,188,000	41,391,000	167,861,000	$15,941,673

SANTA FE COUNTY

Santa Fe County is in northern central New Mexico between Sandoval County on the west and San Miguel County on the east. It occupies a rectangular area of 1,973 square miles.

The principal mineral deposits are contained in a group of hills along the western boundary, named from north to south the Cerrillos Hills, Ortiz Mountains and San Pedro Mountains. These hills consist of laccolithic intrusions into Carboniferous and Cretaceous strata. Placer deposits in this area were highly important at one time. From 1904 to 1930 mines in Santa Fe County produced gold, silver, copper, lead and zinc valued at $2,992,629, about 90 per cent of which was derived from the deposits of the New Placers district. A plant for the production of zinc oxide from carbonate ores was built by the Grubnau Chemical Co. at Waldo on the main line of the Santa Fe in 1917. It operated intermittently from 1917 to 1922. Part of the ore treated came from mines in Mexico.

Production of Metals in Santa Fe County, 1904-1930

	Gold		Silver, ounces	Copper, pounds	Lead, pounds	Zinc, pounds	Total Value
	Lode	Placer					
1904	$ 1,292	$ 4,135	-----	2,308	------	------	$ 5,727
1905	2,241	4,002	42	------	------	------	6,269
1906	7,143	6,737	53	------	------	------	13,916
1907	16,748	1,231	17,635	1,231,260	------	------	275,870
1908	244	1,787	6	------	------	------	2,034
1909	871	1,817	2,295	1,093	213,558	4,426	13,445
1910	3,877	4,262	3,359	5,150	262,023	74,759	26,173
1911	1,825	2,359	2,632	16,644	11,178		7,663
1912	10,216	1,302	14,178	810,563	12,511	10,565	155,272
1913	26,746	129	22,076	1,798,769	794	------	319,053
1914	9,040	1,312	5,723	293,360	52,948	89,860	59,182
1915	42,100	1,567	24,371	1,704,857	50,638	14,556	358,558
1916	66,254	3,112	31,871	2,153,610	166,304	334,321	676,399
1917	7,152	2,155	6,892	400,143	17,779	512,628	178,042
1918	3,981	313	5,244	220,846	28,479	94,572	74,715
1919	1,484	-----	642	3,414	16,623		3,719
1920	1,130	-----	46	2,598	------	37,555	4,700
1921	-----	2,466	5	------	------	------	2,471
1922	10	224	27	2,003	8,800	19,840	2,156
1923	717	970	298	23,102	------	------	5,328
1924	2,553	294	1,788	143,152	5,787	14,400	24,197
1925	5,321	519	10,275	199,770	249,800	170,000	75,991
1926	8,404	197	38,662	177,800	1,077,666	1,234,000	236,381
1927	11,691	2,560	55,157	118,519	2,308,125	2,446,000	356,707
1928	4,192	-----	6,759	257,639	98,535	145,000	59,806
1929	2,425	639	2,486	183,455	------	------	36,677
1930	1,433	127	870	79,100	------	------	12,178
Total 1904-1930	$238,590	$44,216	253,392	9,829,155	4,481,548	5,202,482	$2,992,629

CERRILLOS DISTRICT

The Cerrillos Hills are a few miles north of Cerrillos station on the Atchison, Topeka & Santa Fe railway. Ore was discovered in this district in 1879, but some mining may have been done by the Indians at a much earlier date. The district has been active in varying degrees most of the time since its discovery. Lead, silver and zinc are the principal metals. Official production statistics include the production of this district with that of the Old Placers district, but it is estimated that the value of production from the Cerrillos district from 1904 to 1928 amounted to about $175,000. Most of the ore produced came from the Cash Entry, Grand Central and Tom Paine mines. A small lead smelter at Cerrillos ran intermittently from 1902 to 1904.

The Cerrillos Hills consist of Cretaceous sandstone and shale, which are intruded by a laccolithic mass of monzonite. Numerous small narrow veins carrying silver, lead and zinc occur in the main part of the monzonite and some of them cut across the contact into the surrounding Cretaceous rocks. Argentiferous galena, sphalerite and a little chalcopyrite are the principal ore minerals. The prevailing gangue is quartz and carbonates. Tourmaline is present here and there, and wulfenite is reported. The upper parts of the veins are somewhat oxidized.

GLORIETA DISTRICT

Two kinds of ore deposits occur in the Glorieta district: iron deposits, and copper deposits in the "Red Beds." The iron ore occurs about 5 miles south-southeast of Glorieta and consists of a bed of dark-red, earthy hematite about 3 feet thick in what is probably the top of the "Red Beds." The hematite bed is covered by several feet of yellow clay mixed with concretions of hematite and limonite. Prior to 1905 several thousand tons of fluxing ore were shipped from here to the lead smelters at El Paso, Tex., and Socorro, N. Mex.

The copper deposits occur about 2½ miles northwest of Glorieta along La Cueva Creek in what are probably upper Pennsylvanian strata. Grains of chalcocite occur in a crinoidal limestone bed, and chalcocite, malachite and azurite occur in certain arkose beds. These minerals seem to be most abundant where the sandstones contain the most organic remains.

LA BAJADA DISTRICT[1]

The La Bajada district is southwest of Santa Fe in part of the La Majada land grant. The copper deposits occur in a canyon near La Bajada on the old Santa Fe-Domingo highway. The La Bajada Copper Mining Co. was organized in 1923 to work these deposits, but development work has been unimportant. Chalcocite, chalcopyrite and oxidized copper minerals occur along a rhyolite-limestone contact and as disseminations in porphyry. In addition to copper the ore contains some silver and a little gold. A small shipment of copper-silver ore was made in 1928.

MONTEZUMA DISTRICT

See Santa Fe district.

NEW PLACERS (SAN PEDRO) DISTRICT

The New Placers district, in the San Pedro Mountains, has been one of the richest placer districts of the State, and in addition contains numerous lode deposits of gold, copper, lead and manganese. The placers of this district were discovered in 1839. No figures on the early production of the district are available, but the total was undoubtedly large. From 1904 to 1930 the production of gold, silver, copper, lead and zinc had a value of $2,783,520. The table of production from Santa Fe County, page 95, gives essentially the production from the New Placers district, as all but $209,109 of the county production for 1904-1930 came from this district.

The San Pedro copper mine, one of the largest mines in the district, has been worked intermittently since 1889, though in recent years largely by lessees. It is now the property of the Santa Fe Gold & Copper Co. A smelter, which was built near the mine in 1899, was operated at irregular intervals until 1918. The

[1] Mines Handbook, vol. 18, p. 1674, 1931.

Carnahan Mines Co., controlling several properties including the Amazon, Anaconda and the Lincoln-Lucky group, has been the most important operator during recent years. It operated a selective-flotation mill on complex lead-zinc ore from 1925 to 1928 and shipped a large quantity of lead-silver and zinc concentrates.

The San Pedro Mountains are largely the result of erosion of a granodiorite porphyry laccolith intruded into Pennsylvanian and Permian strata. Contact metamorphism of the sediments is pronounced, especially in the roof of the laccolith. Gold-bearing veins are abundant both in the porphyry and in the altered sediments. Contact-metamorphic copper deposits have formed in the limestone adjacent to the laccolith, and replacement deposits of galena and associated sulphides occur in the limestone farther away. Gold-bearing gravels have accumulated in the erosional debris at the foot of the hills.

The veins carry free gold and pyrite in a quartz-calcite gangue and consist of fracture zones and filled fissures in which the gold is restricted to seams and stringers. They are very narrow, and the gold is erratically distributed. The depth of oxidation rarely exceeds 100 feet.

The contact-metamorphic copper deposits in limestone are confined to the lower part of the sedimentary rocks which form the roof of the laccolith. The limestone has been garnetized and recrystallized. Chalcopyrite is the chief ore mineral, and the ores contain a small quantity of silver and gold. Oxidation is shallow.

The replacement deposits of galena, sphalerite and associated sulphides occur as chimneys and irregular bodies in the limestone. Alabandite, the rare manganese sulphide, is reported in the ores.

The placer gold is contained in detrital fans of sub-angular material at the foot of the San Pedro Mountains, particularly to the north, west and south. A partial concentration of gold has taken place along the creeks and gulches that cut into the gravel. The gravel contains 10 cents or more in gold to the cubic yard, and it is thought that much of the gravel at bedrock may contain $1 or more per cubic yard. The overburden is 10 to 40 feet thick. The gold is generally coarse and rough and is said to be 920 fine. Water for the treatment of these gravels is scarce and must be obtained by drilling. Deep wells have been drilled which yield up to 25 gallons a minute.

OLD PLACERS (ORTIZ, DOLORES) DISTRICT

The Old Placers district is in the Ortiz Mountains between the San Pedro Mountains and the Cerrillos Hills. Gold was first found in New Mexico in this district. The placer deposits were discovered in 1828, and gold-quartz veins were discovered five years later. Placer production to 1904 probably amounted to nearly $2,000,000, but no reliable estimate of lode production prior to 1904 has been noted. Combined production of the Old Placers and Cerrillos districts from 1904 to 1928 is valued at $207,772. The Ortiz mine in Cunningham Canyon has been the chief producer from lode deposits, and the largest ore shoot is said to have been mined between 1854 and 1864. Much of the ore was treated in stamp mills.

The Ortiz Mountains are composed chiefly of a laccolithic intrusion of diorite or monzonite porphyry. The intruded Cretaceous rocks are somewhat metamorphosed. The ore deposits are of three kinds: quartz veins, contact-metamorphic deposits, and gold placer deposits.

The quartz veins occur in brecciated porphyry. Rich ore shoots containing native gold were found in the oxidized zone, generally within 200 feet of the surface. The contact-metamorphic ores are contained in a bed of garnetized limestone and consist in the main of scattered grains of auriferous chalcopyrite which yields free gold on oxidization.

The placer deposits from which the district takes its name at one time constituted one of the most important sources of placer gold in the State. The placer gravels form a mesa which is the upper part of the old alluvial fan. They occupy a large area and increase in thickness with distance from the mountains. In places they are over 100 feet thick. The gold, some of which is coarse, is said to be 918 fine. Each cubic yard of gravel yields, in addition to the free gold recoverable by placer methods, from 3 to 75 pounds of "black sand" containing $4 to $30 a ton in gold. Operations have been severely handicapped by the lack of water. There is not enough for wet methods of operation, and the gravels are too damp for strictly dry methods.

SAN PEDRO DISTRICT

See New Placers district.

SANTA FE DISTRICT

The Santa Fe district as here considered comprises that part of the Santa Fe (Truchas) Range east of the city of Santa Fe, including the areas in the vicinity of Santa Fe Creek and Penacho Peak on the west side of the range, and Dalton and Macho Creeks on the east side. The rocks of the district are pre-Cambrian.

The district contains no important ore deposits. A small amount of flaky gold is reported to occur along Santa Fe Creek, and a little gold is said to occur in a pegmatite dike which breaks through amphibolite. In the Mikado sub-district, on the south side of Santa Fe Creek, gold-silver ore occurs along a fissured zone in aplitic gneiss. Galena, sphalerite and chalcopyrite are present. Small deposits of copper and gold ore are reported on the slopes of Penacho Peak.

Several copper deposits have been prospected on the east side of the range along Dalton and Macho Creeks. The ore occurs chiefly in narrow quartzose zones in amphibolite and carries sphalerite, pyrrhotite and chalcopyrite.

Deposits of molybdenite are reported to have been found in the Santa Fe Range.

SANTA FE MANGANESE DISTRICT[1]

Manganese deposits have been found in the sedimentary area on the west slope of the Santa Fe Range, 4 miles northeast of Santa Fe. The ore occurs largely in soft shale beds as replacement bodies along the bedding. It forms small irregular pockets, and some of it has a nodular structure. Very little ore is in sight, and none has been marketed.

SIERRA COUNTY

The ore deposits of Sierra County have been studied in detail by G. T. Harley, and a comprehensive report is in preparation. It will be issued by the State Bureau of Mines and Mineral Resources of the New Mexico School of Mines as Bulletin 10 entitled "The Geology and Ore Deposits of Sierra County, New Mexico." Some of the information that follows has been taken from the manuscript of this report.

Sierra County, in southwestern New Mexico, has an area of 3,118 square miles. It is bounded on the north and east by Socorro County, on the south by Dona Ana and Luna counties, on the west by Grant County, and on the northwest by Catron County. The Rio Grande traverses the eastern part of the county from north to south. The narrow longitudinal Fra Cristobal and Caballos Ranges lie directly east of the river and extend the entire length of the county. The crest of the Mimbres or Black Range constitutes the boundary between Sierra and Grant counties.

Sierra County was at one time one of the chief metal-producing counties of the State. The principal deposits were discovered in the late seventies and early eighties in the period of great mining activity that followed the construction of the railroads. Kingston, Lake Valley and Hillsboro are the most important districts. Prior to 1904 the Kingston district had produced ore having a value of about $6,250,000, the Lake Valley district about $5,300,000, the Hillsboro district about $6,750,000 and other districts about $1,500,000. The production of the county from 1904 to 1930, exclusive of manganese ores, is valued at $1,201,263, making the total value of production to 1930 about $21,000,000.

[1] Wells, E. H., Manganese in New Mexico, op. cit., pp. 57-58.

Production of Metals in Sierra County, 1904-1930

	Gold		Silver,	Copper,	Lead,	Zinc,	
	Lode	Placer	ounces	pounds	pounds	pounds	Total Value
1904	$ 51,617	$22,979	17,055	16,700	------	-----	$ 86,626
1905	51,164	47,878	8,760	46,664	------	-----	111,666
1906	16,539	1,509	8,102	5,995	------	-----	24,714
1907	7,629	595	2,250	5,425	9,548	-----	11,800
1908	16,039	1,979	8,589	12,874	6,075	-----	24,524
1909	10,450	-----	25,698	25,838	49,023	-----	29,280
1910	11,113	584	15,778	2,448	11,274	-----	21,024
1911	26,962	823	16,487	5,374	28,088	-----	38,459
1912	2,597	1,546	11,236	8,988	21,001	-----	13,481
1913	434	423	2,529	2,568	32,685	-----	4,221
1914	1,305	442	3,982	14,436	5,743	---	6,093
1915	1,079	1,757	316	2,228	24,617	7,492	5,472
1916	1,468	-----	2,138	14,427	126,609	7,045	16,104
1917	1,470	331	8,712	11,828	80,116	-----	19,099
1918	568	-----	18,536	42,053	25,915	-----	31,331
1919	3,948	-----	67,658	31,661	49,679	-----	88,247
1920	15,896	-----	117,089	43,826	84,264	-----	158,328
1921	1,323	-----	77,366	1,395	40,934	-----	80,711
1922	2,708	-----	136,842	38,771	8,746	-----	145,265
1923	6,443	-----	80,814	61,469	12,842	-----	82,645
1924	527	-----	1,297	3,787	4,901	-----	2,284
1925	1,825	-----	23,090	6,300	38,930	----	22,182
1926	4,592	-----	107,973	16,680	298,800	20,500	99,744
1927	8,621	-----	10,300	20,496	123,000	12,000	25,668
1928	3,485	-----	6,754	5,403	146,448	-----	16,708
1929	2,363	520	6,105	7,989	133,030	-----	15,924
1930	3,638	-----	18,465	72,700	400	-----	20,218
Total 1904-1930	$255,803	$81,366	803,921	528,323	1,362,668	47,037	$1,201,263

CABALLOS MOUNTAINS DISTRICT

The Caballos Mountains are on the east side of the Rio Grande and south of Hot Springs. The district, which includes mines and prospects in different parts of the mountains, has been practically inactive for some time. The range is a monoclinal block bounded on the west by a scarp-like front in which is exposed pre-Cambrian granite overlain by an almost complete succession of Paleozoic strata.[1] The mountains are cut by a system of transverse fault fissures.

The copper deposits, which are chiefly along the westward-facing slope of the range south of Palomas, consist of bornite, chalcopyrite and their oxidation products in a quartz gangue. The deposits are small, and most of them occur in the basal Cambrian quartzite just above the granite contact. Galena-fluorite-barite ore occurs in similar fissures in the overlying Carboniferous limestone. The ores are poor in gold and silver.

Vanadinite and cuprodescloizite occur in some of the lead veins in the limestone at and near Palomas Gap.[2] Galena, cerusite and copper carbonates are present, and the gangue minerals are calcite, fluorite, barite and a little quartz. Pyromorphite and wulfenite are present in some of the veins south of the vanadium-bearing area. A plant was erected at Cutter for making vanadium oxide and lead sulphate, but it operated only a short time.

[1] Darton, N. H., op. cit., (U. S. Geol. Survey Bull. 794), pp. 319-324.
[2] Hess, F. L., Vanadium in Sierra de los Caballos, N. Mex.: U. S. Geol. Survey Bull. 530, pp. 157-160, 1912.

Considerable fluorspar ore is available in this region, but most of it will require concentration in order to allow it to compete with other fluorspar on the market.

CHLORIDE (APACHE, CUCHILLO NEGRO, BLACK RANGE) DISTRICT

The Chloride district is in the northwestern part of Sierra County. It includes the Cuchillo Negro district in the Sierra Cuchillo and the contiguous Black Range and Apache sub-districts along the east slope of the Mimbres Mountains, or Black Range. The town of Chloride is about 28 miles northwest of Hot Springs. Ore was discovered in this region in 1879. Production has continued to the present time but has been very small in recent years. The value of the total production from the district probably amounts to about $500,000 in gold, silver, copper and lead.

The rocks of the district consist of Carboniferous strata partly covered by volcanic flows and locally intruded by monzonite porphyry. In the Black Range area the ores occur chiefly as vein deposits in the flow rocks and in a general way are of two kinds: gold-silver ores and silver-copper ores. Most of the gold-bearing veins occur in a northward-trending belt which approximately follows the contact between the limestone and the flow rocks. These veins are fairly persistent. The ores are free milling and usually contain some sulphides. The gangue is made up of quartz and subordinate barite. The silver-copper ores occur west of the gold belt in non-persistent shear zones which carry silver-bearing copper sulphides.

In the Sierra Cuchillo considerable copper ore has been mined from deposits of contact-metamorphic origin. Deposits of iron ore consisting of magnetite and hematite also have been found in the contact zone[1] in garnetiferous rocks. These deposits occur just over the line in Socorro County. (See Iron Mountain district). Extensive prospecting has been done in search of replacement deposits in limestone, and a promising deposit of lead-zinc ore has been partly developed along the monzonite contact on the east slope of the range by the Cuchillo Mines Co. Prospecting has been carried on also in cassiterite-bearing extrusive porphyries and on tin placer deposits along the eastern and southern parts of the range. (See Taylor Creek district).

DERRY MANGANESE DISTRICT[2]

The Derry district is on the west side of the Caballos Mountains about 6 miles northeast of the town of Derry and 13 miles north of Hatch, a station on the Rincon-Deming branch of the Atchison, Topeka & Santa Fe railway. The manganese ore occurs in fissures in limestone along the crest and limbs of a northward-trending anticline. The ore consists of manganiferous and

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[1] Smythe, D. D., A contact metamorphic iron ore deposit near Fairview, New Mexico: Ec. Geol., vol. 16, pp. 410-418, 1921.
[2] Wells, E. H., op. cit., pp. 63-65.

ferruginous calcite accompanied by secondary oxides of manganese and iron and forms fissure fillings and replacement bodies in the fractured limestone.

FRA CRISTOBAL RANGE

The Fra Cristobal Range extends along the east side of the Rio Grande from near Hot Springs northward for about 25 miles. Numerous mineral showings have been reported from these mountains, but the land is held under land-grant title,[1] and prospecting is forbidden.

HERMOSA (PALOMAS) DISTRICT

The town of Hermosa is about 15 miles south of Chloride and about 40 miles west of Engle, a town on the Atchison, Topeka & Santa Fe railway. The district was the scene of great activity in the early mining days, but the mines soon became idle as the principal ore bodies were exhausted. Some of the mines were subsequently reopened, but no important discoveries were made during this later period. The district is said to have produced, up to 1904, ore valued at about $1,250,000.

The rocks of the region consist of volcanic flows flanked on the east by a narrow band of sedimentary rocks which have been exposed by faulting and erosion of the overlying flows. The ore deposits occur just below a shale bed along a flat arch in lower Magdalena limestone and form irregular pockets, lenses and pipes at the intersection of certain strike and dip fractures. The ores are composed of silver-bearing sulphides of lead, copper and iron in a gangue of talcose clay. Native silver is common, but in the high-grade ore, which runs from 300 to 700 ounces of silver to the ton, the silver is contained in argentiferous galena and bornite.

HILLSBORO (LAS ANIMAS) DISTRICT

Hillsboro is 17 miles north of Lake Valley and 16 miles west of the Rio Grande. This district is one of the most important in Sierra County. The principal mines are the Bonanza and the Rattlesnake. The value of the total production of the district from 1877, the year in which gold was discovered here, to 1904 has been estimated at $6,750,000, chiefly in gold. Since then operations have been intermittent and as a rule on a small scale.

The rocks of the Hillsboro district consist of lower Paleozoic sediments cut by monzonite porphyry and capped by Tertiary andesite (or latite) flows. Three kinds of deposits occur in the district: (1) Oxidized ores in the Mimbres limestone, containing lead, manganese, iron, vanadium and molybdenum; (2) ores containing gold, silver and copper in veins or shear zones in the andesite; and (3) placers.[2]

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[1] Fowler, C. H., Mining and mineral laws of New Mexico: N. Mex. Sch. of Mines, State Bur. of Mines and Min. Res. Bull. 6, 1930.

[2] See Las Animas placer district, p. 105.

The oxidized ores, in which lead and vanadium are the important metals, contain cerusite, wulfenite and vanadinite and form lenses distributed along the contact between the limestone and the overlying Percha shale. They occur at a number of places over an area of several square miles but apparently do not extend far from the surface. A considerable amount of manganese is associated with the ore, and deposits consisting primarily of manganese minerals occur locally.[1] Some siliceous limonite ore has been mined for fluxing purposes.

The gold-silver ores constitute the principal deposits of the district. They occur in quartz veins and consist chiefly of copper sulphides carrying gold and silver but also contain a little free gold. Most of the veins are narrow but high grade. They appear to converge toward an intrusive mass of monzonite porphyry at Copper Flat near Animas Peak.

HOT SPRINGS (MUD SPRINGS) DISTRICT

The Hot Springs district is west-northwest of the town of Hot Springs. The manganese deposits[2] are adjacent to the town and consist of soft, incoherent sandstone beds of Santa Fe and later age, which locally contain considerable psilomelane and wad. Psilomelane is the most abundant manganese mineral and occurs both as a cementing material and as a replacement of individual grains, changing the loosely consolidated sandstone to a hard, compact, resistant rock. Considerable ore is in sight, but the average manganese content is low. These deposits are unique among the manganese deposits of New Mexico.

Copper and silver veins have been prospected along the southwest face of the Mud Springs Mountains in the western part of the district. Bunches of chalcopyrite, bornite and oxidized copper minerals have been found in the basal part of the Bliss (Cambrian) quartzite along several transverse fissures. The veins are richer in silver higher up in the quartzite and in the overlying El Paso limestone, and these portions are credited with a production of horn silver valued at about $40,000. This class of ore in the known veins has been largely worked out.

KINGSTON (BLACK RANGE) DISTRICT

Kingston is on the east slope of the Black Range 8 miles nearly due west of Hillsboro and about 3 miles east of the Grant County line. Silver is said to have been discovered here in 1880. The principal producing mines were the Lady Franklin, Kangaroo, Caledonia, Comstock, United States, Illinois, Calamity Jane and Brush Heap. The value of production up to 1904 has been estimated at $6,250,000, nearly all in silver, making the district the largest producer of silver in New Mexico up to that time.

[1] Jones, E. L., Jr., Deposits of manganese ore in New Mexico: U. S. Geol. Survey Bull. 710, pp. 48-50, 1919.

[2] Wells, E. H., op. cit., pp. 61-63.

Owing to the decrease in the price of silver in the early years of the present century, this camp suffered with the other silver camps at that time, but it was able to continue production at the rate of a car or more of ore each year.

The ore deposits of the Kingston district are similar to those of the other districts in the Black Range. In addition to silver they contain lead, copper and manganese.[1] The ores are distributed along fractures in the limestone and occur in pockets and pipes along low, gently pitching arches in Ordovician limestone below a silicified zone adjacent to the overlying Percha shale. The principal ores consist of oxidized lead, copper and manganese minerals carrying silver and gold in a clay gangue. Sphalerite is generally present, and the rare manganese sulphide, alabandite, is found occasionally. Argentite, native silver, and cerargyrite occur. Rhodochrosite and rhodonite are among the primary gangue minerals. Oxidation of the manganese minerals has formed impure bodies of manganese oxides, and it is estimated that many thousand tons of low-grade manganese ore exist in the district.

LAKE VALLEY DISTRICT

Lake Valley is the terminus of a branch line of the Atchison, Topeka & Santa Fe railway which connects with the Rincon-Silver City branch at Nutt, 13 miles to the southeast. Ore was first discovered in the district late in 1878. The famous Bridal Chamber, one of the richest single bodies of silver ore ever found, was discovered in the early eighties. The mines were closed in 1893, up to which time production amounted to approximately 5,000,000 ounces of silver. The Bridal Chamber alone produced half of this quantity. Small shipments were made from time to time up to 1930, but much of these later shipments has consisted of iron-manganese-silver ore used as flux in the lead smelter at El Paso, Tex. During the early days of mining the chief properties were the Sierra Grande, Sierra Bella and Sierra Apache. The operation of these mines was conducted under the management of the Sierra Grande Co.

The ores occur in the Lake Valley (Mississippian) limestone, usually in the lower beds but in places along the contact with overlying shale, and commonly follow the bedding of the rocks. They occur near the surface in a zone several hundred feet wide and are close to a prominent intrusion of porphyry. The ore bodies are highly irregular in size and shape and are almost completely oxidized. Cerargyrite is the chief mineral of the silver ore, but other silver minerals are present. Some of the ore contains highly argentiferous cerusite and galena, but sulphides other than galena are rare. Iron and manganese oxides are abundant as gangue minerals and the ores are colored

[1] Wells, E. H., op. cit., pp. 67-68.
Jones, E. L., Jr., op. cit., pp. 50-51.

brown or black by them. The manganese ore[1] consists largely of manganite, pyrolusite, psilomelane, wad and limonite. The silver content of the ore runs as high as 500 ounces to the ton and manganese ranges from 12 to 40 per cent. Zinc, copper and gold occur in very small amounts. The approximate average content of a year's shipments from one mine is as follows: Silver, 48 ounces per ton; lead, trace; zinc, 4 per cent; iron, 14 per cent; manganese, 18 per cent. Considerable manganese ore low in silver was left unmined or thrown on the dumps.

LAS ANIMAS (GOLD DUST) PLACER DISTRICT

Dry placer mining was at one time productive in the Las Animas district about 6 miles northeast of Hillsboro. The gold was derived from the eroded parts of the gold veins of the Hillsboro district. The placer deposits have been described as follows:[2]

> The dry placers cover several square miles from one-half inch to several feet in depth. Gold is practically all worked on false bedrock. Nothing is known of the original bedrock. Fake tests have averaged $1.25 per cubic yard, but average working tests from 22 to 25 cents. The largest nugget found was valued at $85, and the fineness of the gold ranged from 0.945 to 0.956. * * *

Two areas that have been recently sampled and worked on a larger scale than heretofore attempted, indicate that in parts of the deposits covering areas of as much as several acres each, the recoverable gold content ranges from 30 to 80 cents a cubic yard, the average in these areas being about 60 cents. Considerable capital and work have been expended in recent years on a part of the Las Animas district farther east called the Gold Dust district,[3] but there is no authentic record of any important amount of gold having been recovered from the gravels at this place. The total amount of gold in the district is undoubtedly large, but most of the placer ground is low grade.

MACHO DISTRICT

The Macho district is about 5 miles southwest of Lake Valley. Approximately 1,700 tons of lead-silver-gold ore was shipped from this district in 1926-1928. Underground workings total only about 1,300 feet. The prevailing andesite of the district is cut by a number of radiating dikes of latite, and the ore occurs in rather narrow veins along the dikes. The important minerals are galena and cerusite. Sphalerite is present in small amounts.

PITTSBURG (SHANDON) DISTRICT

The Pittsburg placer district lies near the western foot of the southern end of the Caballos Mountains, about 20 miles northwest of Rincon and due east of Hillsboro.

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[1] Wells, E. H., op. cit., pp. 58-61.
Jones, E. L., Jr., op. cit., pp. 46-48.
[2] U. S. Geol. Survey Mineral Resources, 1912, pt. 1, p. 262, 1913.
[3] Wells, E. H. and Wootton, T. P., Gold mining and gold deposits in New Mexico: N. Mex. Sch. of Mines, State Bur. of Mines and Min. Res. Circular No. 5, p. 20, 1932.

The gold is distributed in granitic detrital material over a limited area west of the granite escarpment of the Caballos Mountains. The gold is coarse and unworn and becomes gradually less abundant toward the escarpment.

It is roughly estimated that the Pittsburg placers have produced about 2,500 ounces of gold.

SAN MATEO MOUNTAINS

The southern end of the San Mateo Mountains, which extend into Sierra County, is made up of basal flows of andesite and andesite breccia, and overlying rhyolite tuffs, breccias and flows. A little prospecting has been done in this region, principally in the Goldsboro district, 28 miles northwest of Hot Springs, where a few tons of silver-bearing galena ore has been mined and shipped. There has been some prospecting for gold, but no commercial bodies of ore have been found. On the southwest flank of the range, near the Red Rock ranger station, copper prospects have been partly developed in the andesite in what is seemingly an extension of the "Nigger Diggings" area in Socorro County.

A little prospecting has been done at Quartz Mountain, a small mountain of silicified rhyolite south of the main range, on quartz veins reported to contain $2 to $3 worth of gold per ton. Only a moderate amount of development work has been done at this place, and apparently no shipments of ore have been made.

TAYLOR CREEK DISTRICT

This district is described under Catron County.

TIERRA BLANCA (BROMIDE NO. 1) DISTRICT

The Tierra Blanca district is about 15 miles northwest of Lake Valley and just south of the Kingston district. Both silver and gold ores occur in the district. The history of this camp is similar to that of the other camps of the Black Range. Mining was carried on vigorously for a brief period following its discovery, but it has been practically idle for many years.

The silver ores occur as pockets and pipes in Lake Valley (Mississippian) limestone just beneath or not far below a bed of shale. The silver occurs in the native form and in copper and lead sulphides, and subordinately as argentite, silver chloride, and silver bromide. Gold is found in the upper silicified part of the Mimbres limestone. Small pockets of hessite intergrown with native gold have been mined from this formation in the Lookout mine. Gold[1] is also said to occur in quartz gangue in a pipelike body in pre-Cambrian (?) granite in this district.

[1] Ballmer, G. J. Santa Rita, N. Mex., oral communication.

SOCORRO COUNTY

The ore deposits of Socorro County are described in detail by S. G. Lasky in Bulletin 8 of the State Bureau of Mines entitled "The Ore Deposits of Socorro County, New Mexico," issued in 1932. Most of the information on Socorro County in this report is summarized from Bulletin 8.

Socorro County, the largest county in New Mexico, covers an irregular area of approximately 7,550 square miles in the southwest-central part of the State. The county is in an area of desert basins out of which a number of mountain peaks and ranges rise rather abruptly. The Rio Grande Valley roughly bisects the county from north to south and separates it into two distinct parts, geologically as well as physically. East of the river the pre-alluvium rocks consist chiefly of Carboniferous and Cretaceous sedimentary formations and the usual underlying pre-Cambrian complex. The non-alluvial area west of the river is floored mostly by volcanic rocks.

The west side of the Rio Grande Valley is bounded by the Ladrones, Lemitar, Socorro and San Mateo Mountains, named from north to south. The Magdalena Range is in the west-central part of the county. The Joyita Hills are on the east side of the river about 15 miles north of Socorro. The long and narrow southward continuation of Socorro County includes the northern part of the San Andres Mountains which are continued to the northeast by the Oscura Mountains.

Owing to production from the Magdalena district, Socorro County was for many years one of the chief producers of metals in New Mexico. Gold, silver, copper, lead, zinc and bismuth have been marketed. Tin and vanadium ores also occur. The total production of the county to 1930 is valued at $30,250,000, of which over $17,000,000 represents the zinc output. The accompanying table gives the annual production of metals from 1904 to 1930. Socorro County included the area now covered by Catron County up to July 1, 1921, and although production figures for the two areas may be segregated as far back as 1904, it is impossible to do so prior to that date.

Production of Metals in Socorro County, 1904-1930

	Gold	Silver, ounces	Copper, pounds	Lead, pounds	Zinc, pounds	Total Value
1904	$ 39,792	6,457	3,200	688,209	13,493,835	$ 761,726
1905	20,277	4,810	320,000	390,000	14,630,051	954,684
1906	------	2,515	64,560	238,088	17,044,163	1,067,435
1907	13	4,406	38,645	707,981	676,356	88,078
1908	20,472	1,152	19,462	16,073	3,325,446	180,623
1909	25,035	19,648	170,792	3,085,279	12,878,241	885,549
1910	6,904	66,331	152,284	3,452,364	16,727,870	1,117,272
1911	2,895	42,907	77,448	2,123,039	9,930,281	696,879
1912	771	33,281	89,592	2,192,792	9,962,487	822,109
1913	3,970	40,394	285,148	2,198,030	13,267,811	912,276
1914	2,265	14,436	214,722	674,205	13,785,176	768,174
1915	488	56,941	1,416,098	2,031,297	18,437,218	2,658,860
1916	2,057	73,228	1,012,406	4,421,290	19,312,179	3,192,194
1917	2,186	137,250	2,699,333	4,885,210	14,716,745	2,773,434
1918	430	49,976	585,482	3,078,098	11,501,879	1,460,236
1919	10	30,117	599,382	819,566	2,995,740	407,352
1920	------	18,367	311,663	873,012	3,764,235	452,110
1921	------	155	------	60,711	133,000	9,537
1922	207	6,156	8,063	923,541	3,119,298	236,046
1923	455	15,721	50,388	1,506,829	3,421,000	358,859
1924	199	10,643	94,626	1,636,825	3,823,800	399,219
1925	1,154	25,182	83,300	2,444,600	3,170,000	484,059
1926	606	14,575	56,714	1,400,200	8,013,300	730,654
1927	775	70,478	173,817	1,637,667	4,430,000	450,199
1928	1,980	16,183	128,327	991,207	339,000	108,095
1929	289	15,060	184,483	961,270	254,000	118,109
1930	113	7,808	72,900	982,300	1,470,000	132,271
Total 1904-1930	$133,343	784,177	8,912,835	44,419,683	224,623,111	$22,225,989

CAT MOUNTAIN DISTRICT

Cat Mountain is an island of Tertiary lavas within the alluvium about 13 miles by road southwest of Magdalena. Low-grade gold-quartz veins with short and inconspicuous exposures crop out in andesite and rhyolite in this district.

The district has been idle since 1903. Production is insignificant.

CHUPADERO DISTRICT

The Chupadero mines are about 6 miles northeast of Socorro on the east side of the Rio Grande. Copper carbonates occur mainly in a thin-bedded sandstone layer of the Magdalena formation. In the same general area galena, barite and fluorite occur in a calcareous sandstone member of the Chupadera formation.

The amount of work that has been done is insignificant. The district has been abandoned for many years.

COUNCIL ROCK DISTRICT

The Council Rock district is about 10 miles northwest of Magdalena at the edge of the Tertiary lavas bordering the San Agustin Plains.

The ore, which is said to have consisted of argentiferous lead carbonates, occurred locally along silicified fault fissures. The veins were worked in the early eighties, and nothing is known of the production.

HANSONBURG (CARTHAGE) DISTRICT

The Hansonburg district is at the eastern edge of the Jornada del Muerto, about 32 miles slightly south of east from San

Antonio. The copper ores of the district first attracted attention in 1872. The lead ores were discovered later. Operations in the district have been intermittent since its discovery. In 1916 a dry concentrating mill was built to treat the lead ores at the McCarthy mine. In all, about 15 cars of copper ore and several cars of lead concentrate have been shipped.

The deposits occur as cavity fillings in localized areas along members of the fault zone that controls the western face of the northern Sierra Oscura. They are chiefly in the Magdalena limestone. The deposits show normal primary zoning of copper and lead. Mineralization along any single vein is discontinuous, and the ore is pockety.

The lead ores consist essentially of argentiferous galena in a fluorite-barite gangue in highly silicified limestone. A very small amount of chalcopyrite is present in addition to several oxidation products of lead and copper. Where chalcopyrite is most abundant, stains of cuprodescloizite (?) are present.

Tennantite is the chief mineral of the copper deposits and occurs in a dolomite gangue. Lead is entirely absent. The ore is stained with copper arsenates and carbonates.

HOP CANYON DISTRICT

The Hop Canyon district is on the west side of the Magdalena Mountains about 3 miles south of Kelly. A small amount of prospecting has been done along shear zones in the volcanic rocks, but no ore bodies have been encountered.

IRON MOUNTAIN DISTRICT

The Iron Mountain iron deposits are in the eastern foothills at the northern end of the Cuchillo Mountains, about 12 miles north of Fairview. So far as is known, the district has no production to its credit.

The limestone of the district has been intruded by an elongate body of porphyry and has been strongly metamorphosed adjacent to the intrusion. The ore occurs in the limestone near the contact with the porphyry. As exposed at the surface, the main ore bodies are roughly lens-shaped, ranging from 60 to 250 feet in width and averaging 1,200 feet in length. The ore minerals are magnetite and hematite. The ore bodies are overlain by beds of nearly pure garnet, and a little garnet occurs in the ore. The average grade of the ore is about 45 per cent iron.

JONES CAMP

The Jones iron deposits are in the northern Oscura Mountains about 47 miles east of San Antonio. The deposits, which are of the contact-metamorphic type, occur in Chupadera limestone in irregular bodies adjacent to a wide monzonite dike. Magnetite is the dominant ore mineral. The deposits are fairly large and of good grade. They have been known for many years, but no ore has been marketed.

JOYITA HILLS (CANYONCITO) DISTRICT

The Joyita Hills consist of a pre-Cambrian granite core between Carboniferous strata and Tertiary volcanic flows. These hills form a short longitudinal range about 5 miles long on the east side of the Rio Grande, approximately 5 miles east-northeast of San Acacia, a station on the Atchison, Topeka & Santa Fe railway 13 miles north of Socorro. The deposits of the district have not been developed beyond the prospect stage.

The ore deposits occur as fissure veins in pre-Cambrian rocks and as open-space filling and replacement bodies in silicified Magdalena limestone. They show a distinct spacial relationship to the granite core. Galena poor in silver is the chief ore mineral, and a small amount of copper occurs locally. Most of the vein matter consists of gangue minerals, which include fluorite, barite and quartz.

LADRONES MOUNTAINS DISTRICT

The Ladrones Mountains are about 15 miles northwest of San Acacia. They consist essentially of a large mass of pre-Cambrian granite bordered on the west slope by sedimentary rocks and nearly surrounded by Tertiary sands and conglomerates and Quaternary alluvium.

Two small mineral exposures have been found. At one of these chalcocite and oxidized copper minerals in a quartz-fluorite gangue occur as open-space filling in the granite adjacent to an andesite dike. At the other, copper minerals occur disseminated in loosely-cemented Tertiary arkose and in an adjacent basaltic dike which separates the arkose from pre-Cambrian granite. Copper carbonates and silicate form cementing materials in the arkose, and the mineralized granite and dike rock contain disseminated microscopic particles of sulphides.

LEMITAR MOUNTAINS DISTRICT

Lead ore occurs as a fissure filling in small scattered pockets along the contacts of granite with schists and with basic dikes in the pre-Cambrian area at the east base of the Lemitar Mountains, about 3½ miles west of the town of Polvadera. The ore contains galena and here and there small amounts of chalcopyrite or sphalerite. The gangue minerals are quartz, barite and fluorite. A small pocket of oxidized zinc ore has been mined.

LUIS LOPEZ MANGANESE DISTRICT[1]

The Luis Lopez district is 5 miles west of the village of Luis Lopez, 5 miles south of Socorro. The principal ore-bearing rocks are strongly faulted Tertiary lavas in which the ore commonly occurs along well-defined fissures. Considerable manganiferous calcite is associated with the manganese oxides of the ore. Psilomelane occurs as a cement in some of the gravel at the foot of the hills.

[1] Wells, E. H., Manganese in New Mexico: N. Mex. Sch. of Mines, Min. Res. Survey Bull. 2, pp. 78-81, 1918.

MAGDALENA DISTRICT

A detailed study of the geology and ore deposits of the Magdalena district has been made by the United States Geological Survey and the State Bureau of Mines and Mineral Resources of the New Mexico School of Mines under a co-operative agreement, and a comprehensive report on the district is in preparation. This report will be issued by the United States Geological Survey.

The Magdalena district is near the north end of the Magdalena Mountains, and lies chiefly on the west slope. The mining camp of Kelly is adjacent to the most productive area. Kelly is about 3 miles southeast of Magdalena, which is the terminus of the branch line of the Atchison, Topeka & Santa Fe railway between that town and Socorro.

Ore was first discovered in the district in 1866 by Col. J. S. Hutchason. The first ores mined were oxidized lead ores. These were smelted in an adobe furnace and the product hauled to Kansas City by ox teams. In 1881 a smelter was erected at Socorro by Gustav Billing, which treated ores from the Kelly mine in this district. It closed in 1893. The Graphic smelter, built at Magdalena in 1896, operated intermittently until 1902. From 1894 to 1902 the Kelly and Graphic mines, the chief properties, were worked with fair regularity. Zinc carbonate ore was discovered in 1903, and this discovery resulted in a marked revival of mining. The Graphic mine was purchased by the Ozark Smelting & Mining Co., a subsidiary of the Sherwin Williams Paint Co., and the Kelly and Nitt mines were acquired by the Tri-Bullion Mining & Development Co. Zinc carbonate ores constituted most of the production of the district from 1903 to 1906. From 1907 to 1920 the chief production came from zinc-lead sulphide ores which were milled in the district or shipped to smelters outside the state. During this period the Nitt mine of the Tri-Bullion Mining & Development Co. produced a moderate amount of sulphide ore. The Kelly mine was purchased by the Empire Zinc Co. in 1913. Mining operations were greatly curtailed following the World War, but a moderate production, largely of carbonate ores, was maintained from 1922 to 1928. The Ozark Smelting & Mining Co. mined and milled a considerable tonnage of sulphide ores in 1926 and 1927.

The Magdalena district was the principal zinc producer in New Mexico for many years, and 46 per cent of the zinc output of the State from 1904 to 1928 came from this district. For the same period it accounted for 34 per cent of the lead production of the State. The value of the production from 1904 to 1930 was $22,080,013, in zinc, lead, copper, silver and gold. The value of the entire production from the discovery of the district to 1930 was about $28,640,000.

In the Magdalena district the Magdalena Mountains consist of a core of pre-Cambrian granite and argillite overlain by westward-dipping sedimentary rocks of Mississippian, Pennsylvanian and Permian age. The dip of the sedimentary rocks on the west side of the range is somewhat greater than the average surface slope. East of the crest pre-Cambrian rocks predominate. To the south, the sedimentary strata are overlain by lava flows which form the most prominent part of the range. Several large stocks and dikes of Tertiary monzonite and related rocks occur in the northern part of the district. Faults are numerous and are important structural features of the area.

The Lake Valley (Kelly) limestone of Mississippian age is the basal sedimentary formation of the district. It is a crystalline crinoidal limestone about 125 feet thick with a thin bed of quartzite at the base. Near the middle of the formation is the "Silver Pipe" stratum, a gray to black, sub-lithographic, dolomitic limestone 5 to 10 feet thick. The Lake Valley limestone is overlain by rocks of the Magdalena group. The upper part of this group consists chiefly of massive limestone and smaller amounts of shale and quartzite and is called the Madera limestone. The lower part consists of shale, quartzite and subordinate limestone, and is known as the Sandia formation. The Permian Abo formation, consisting of sandstone and shale, overlies the Magdalena group in places.

The principal metallization is confined to a zone in the sedimentary rocks which begins at the contact of a monzonite stock in the north central part of the district and extends southward nearly 4 miles. Almost all the known ore bodies are replacement deposits in the Lake Valley limestone. They commonly are adjacent to and above or below the "Silver Pipe" member. Several other ore horizons occur in the Lake Valley limestone and in the Magdalena group. A little mineralization occurs in monzonite, in extrusive igneous rocks and in pre-Cambrian rocks, but these deposits are economically unimportant.

Both primary and secondary ores occur in the district. Near the monzonite contact the primary ores are of the contact-metamorphic type. Adjacent to the contact they consist principally of specularite, magnetite and subordinate sulphides; in places the sulphides, chiefly pyrite, sphalerite, and chalcopyrite, are economically important. Pyroxene, amphibole and chlorite are prominent in the outer part of the contact-metamorphic zone, and garnet is present locally. The contact-metamorphic ores grade southward into typical lower temperature replacement bodies of sphalerite, galena and minor chalcopyrite. Lead becomes more abundant and zinc less abundant as distance from the contact increases. Gangue minerals, which consist chiefly of quartz and calcite, occur in small amounts only. Barite is present locally in the sulphide zone but is most abundant beyond the limits of intense mineralization. Fluorite is occasionally present and is locally abundant in the outlying parts of the district. Primary ore deposition probably occurred in Tertiary time.

Secondary oxidized ores derived from the primary ores occur near the surface. During oxidation the lead and zinc were segregated into different bodies, the zinc carbonate ore forming a more or less regular shell partly enclosing lead carbonate ore of high purity. Smithsonite and cerusite are the most important oxidized minerals, but others present include anglesite, cuprite, malachite, azurite, aurichalcite, goslarite and chalcanthite.

Production of Metals in the Magdalena District, Socorro County, 1904-1930

	Gold	Silver, ounces	Copper, pounds	Lead, pounds	Zinc, pounds	Total Value
1904	$ 154	5,024	3,200	688,209	13,493,835	$ 721,257
1905	-----	4,800	320,000	390,000	14,630,051	934,351
1906	-----	2,515	64,560	238,088	17,044,163	1,067,435
1907	13	4,406	24,045	707,981	676,356	85,158
1908	72	460	2,605	16,073	3,325,446	157,631
1909	435	17,925	170,792	3,085,279	12,878,241	860,051
1910	468	65,880	152,181	3,451,228	16,727,870	1,110,529
1911	352	42,773	77,448	2,123,039	9,930,281	694,266
1912	746	32,792	69,532	2,192,792	9,962,478	818,473
1913	3,942	40,212	278,252	2,198,030	13,267,811	911,069
1914	2,265	14,436	214,722	674,205	13,785,176	768,144
1915	488	56,897	1,406,789	2,031,297	18,437,218	2,657,209
1916	2,036	72,877	993,199	4,421,290	19,312,179	3,187,217
1917	2,186	137,114	2,690,381	4,885,210	14,716,745	2,770,878
1918	430	49,835	585,482	3,033,535	11,501,879	1,456,931
1919	10	30,117	599,382	819,566	2,995,740	407,352
1920	-----	18,367	311,663	873,012	3,764,235	452,110
1921	-----	155	------	60,711	133,000	9,537
1922	207	6,156	8,063	923,541	3,119,298	236,046
1923	455	15,721	50,388	1,506,829	3,421,000	358,859
1924	199	10,643	94,626	1,636,825	3,823,800	399,219
1925	1,154	25,073	82,800	2,434,600	3,170,000	483,042
1926	606	14,575	56,714	1,400,200	8,013,300	730,654
1927	775	70,478	173,817	1,637,667	4,430,000	450,199
1928	1,980	16,183	128,327	991,207	339,000	108,095
1929	285	15,032	174,483	961,270	254,000	116,330
1930	109	7,426	50,100	958,600	1,470,000	127,971
Total 1904-1930	$19,367	777,872	8,783,551	44,340,284	224,623,102	$22,080,013

MAGDALENA MOUNTAINS MANGANESE DISTRICT[1]

The manganese-bearing area of the Magdalena Mountains is in the southeastern part of the range from Water Canyon southward. Water Canyon station on the Socorro-Magdalena branch of the Atchison, Topeka & Santa Fe railway is 4½ miles east of the mouth of Water Canyon.

This part of the Magdalena Mountains is composed almost entirely of Tertiary volcanic rocks, chiefly rhyolite and associated tuffs and breccias. Manganese veins are numerous, but most of them are unimportant. The ore is mainly in rhyolite and occurs in fissures and brecciated zones. The veins range in thickness from a few inches to 4 feet. At the Water Canyon mine, where the most important vein of the district occurs, the best ore was at a depth of 20 to 60 feet below an inconspicuous outcrop. The

[1] Wells, E. H., op. cit., pp. 69-75.

ores consist of manganese oxides associated with limonite and manganiferous calcite.

The only production has been from the Water Canyon mine in Water Canyon, which produced 864 tons of high-grade manganese ore during the World War.

MILL CANYON DISTRICT

The Mill Canyon district is 13 miles by road south of Magdalena. It is near the crest of the Magdalena range on the west side. Copper and lead mineralization occurs in the volcanic rocks, which consist chiefly of andesite. The principal ore body occurred in shattered andesite porphyry and contained considerable cuprite; at depth this graded into a mixture of oxide and sulphide minerals of copper containing a notable proportion of covellite. The ores carried some gold.

NIGGER DIGGINGS

The "Nigger Diggings" are in the southern part of the San Mateo Mountains and about 4 miles southwest of the Rhyolite mine in the San Jose district. The deposits are reported to have been worked by Negro soldiers stationed at Ojo Caliente in the early days. It is said that a small adobe furnace was constructed and that the ore was smelted for its silver content. The workings have been idle most of the time since the discovery of the deposits in 1887, but small-scale operations have been undertaken at various times.

The mineralization occurs in a wide northward-trending shear zone in highly altered andesite. The rather weak veins contain small amounts of copper carbonates. No commercial ore is in sight.

NORTH MAGDALENA DISTRICT

The North Magdalena district includes a number of claims and prospects in the volcanic rocks a short distance northwest of Magdalena.

Nearly all the veins have long outcrops and seem to be of the shear-zone, fault-contact type. The deposits consist of copper-silver and lead-vanadium ores. The copper-silver ores contain oxidized copper minerals, chalcocite, covellite and a valuable proportion of argentite. They occur in small pockety shoots and fill fissure and breccia openings. The lead-vanadium ore occurs along fault fissures which locally follow basic dikes. Galena is the chief ore mineral, but vanadinite, descloizite and copper minerals are locally present. In some veins the type of mineralization exposed seems to bear a decided relationship to the kind of wall rock or breccia in the vein. Gold is said to have been mined from similar veins which carried only a trace of base metals.

OJO CALIENTE DISTRICT

A small lead prospect, known as the Taylor prospect, occurs on the southwest edge of the San Mateo Mountains, about 2 miles southeast of the old fort of Ojo Caliente and about 16 miles north of the Chloride district. No shipments have been made.

The ore occurs in a quartz vein in altered andesite and is completely oxidized. Cerusite is the chief ore mineral. Oxidized copper and zinc minerals and manganese and iron oxides accompany the cerusite. Copper minerals gradually increase with depth. The ore is said to carry about 13 ounces of silver and a small amount of gold a ton.

RAYO DISTRICT

Rayo is about 12 miles south of Scholle, a station on the Belen cut-off of the Atchison, Topeka & Santa Fe railway. The ore consists of copper carbonates and nodules of chalcocite in gray, loosely cemented Abo sandstone. Carbonaceous matter does not seem to be present.

Workings consist almost entirely of trenches and cuts. A trifling amount of ore that may have been taken out in the course of prospecting constitutes the only production.

ROSEDALE DISTRICT

The Rosedale district is in the San Mateo Mountains about 25 miles southwest of Magdalena. Gold was discovered here in 1882, and mining operations were fairly continuous until 1916. Most of the ore mined was treated by almagamation and cyanidation in a 10-stamp mill. Production was appreciable, but no figures are available.

The ore occurs in well-marked brecciated and sheared zones in rhyolite porphyry and carries free-milling gold. The silicified outcrops stand out clearly. Much manganese dioxide is present locally and is said to be associated with the higher grades of ore. Silver is locally present in small quantities.

SAN ANDRES MOUNTAINS

The San Andres Mountains in eastern Socorro County begin at San Agustin Pass, northeast of Las Cruces in Dona Ana County, and extend nearly due north to Mockingbird Gap in Socorro County, a distance of nearly 75 miles. The ore deposits of this range probably became known soon after the discovery of the Organ district in 1849. Numerous deposits are scattered throughout the length of the range, but none has been developed beyond the earliest prospect stage. A small amount of ore has been gophered out of the different prospects.

The range is structurally a westward-dipping monocline consisting of a succession of Paleozoic rocks overlying the pre-Cambrian complex, which is exposed on the steep eastern face. The strata are cut by faults and intruded by masses of monzonitic rock. Practically all the deposits occur along the eastern side of the range. For the most part they are fissure veins along small faults. Deposits of copper, lead, zinc, bismuth and tungsten occur.

Goodfortune Creek District.—The Goodfortune Creek district is about 45 miles west of Tularosa, on the steep eastern slope of the San Andres Mountains. The veins follow transverse faults and fissures. The ores consist chiefly of silver-bearing secondary chalcocite and copper oxidation products and are most abundant at the contact between the pre-Cambrian granite and the overlying Cambrian quartzite.

Grandview Canyon (San Andres) District. — Grandview Canyon is on the eastern slope of the San Andres Mountains, about 40 miles west of Tularosa. The ore deposits lie within pre-Cambrian rocks, which are chiefly granite and schist, and contain bismuth, tungsten and copper. The bismuth minerals are found in pockets of various sizes enclosed within quartz lenses in schist. The ore minerals are bismuthinite, native bismuth and bismutite. A small body of scheelite was found with the bismuth ore. Pyrite and chalcopyrite are locally present in small amounts. The copper ore occurs in a sheared hornfels-like rock as pods and veinlets of chalcopyrite and calcite in isolated shoots and bunches.

Mockingbird Gap District.—Mockingbird Gap is the pass between the Oscura and San Andres Mountains. Most of the deposits of the district lie in the San Andres Mountains south of the gap. Copper and lead-zinc ores are found along fault fissures in the pre-Cambrian and Paleozoic rocks. The copper ores occur near the granite-sedimentary contact and are similar to the ores of the Goodfortune Creek district though in general much more oxidized. The lead-zinc ores consist of galena and sphalerite, partly oxidized, in a calcite-quartz-barite gangue. A moderate quantity of silver is present.

Salinas Peak District.—Salinas Peak is an intrusive porphyry mass in the northern part of the San Andres Mountains about 30 miles west of Three Rivers. Copper-lead ore occurs along a fault contact between the porphyry and Magdalena limestone. The vein is several feet wide and carries galena and chalcopyrite and their oxidation products.

Sulphur Canyon District.—Sulphur Canyon is on the eastern slope of the San Andres Mountains about 4 miles north of Grandview Canyon. The copper ore of this district occurs in pre-Cambrian schist and consists of oxidized copper minerals in a lens of coarsely crystalline chlorite. The single ore body seems to have been entirely worked out.

SAN JOSE (NOGAL) DISTRICT

The San Jose district is near the crest of the rugged southeastern part of the San Mateo Mountains. It is 20 miles south of the Rosedale district. The gold-bearing veins of the district have been known for many years, but the district received very little attention until the summer of 1931 when high-grade gold-silver ore was discovered in the outcrop of the Pankey vein. The entire production of the district up to June, 1932, was from the

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Pankey outcrop and consisted of 160 tons of ore which had a gross value of $1,387. Very little development work has been done on any of the veins.

All the rocks of the San Jose district are volcanic in origin. They consist chiefly of lava flows but include a little breccia and tuff and a few dikes. The district contains several prominent faults and numerous minor breaks. All the faults and many of the minor fractures are mineralized, but mineralization is essentially confined to a brittle, unaltered brown rhyolite, which is 1,100 feet or more thick.

The veins are rather tight and are made up of irregular stringers, some of which are as much as 3 feet in width. Brecciation is a common feature. The vein filling is essentially hornstone quartz and lamellar calcite, but a little fluorite is present in parts of some of the veins. Banding is prominent here and there. The valuable metals are gold and silver. Native gold, native silver, cerargyrite, stephanite (?) and pyrite are the important minerals at and near the surface. The native gold has been derived from the pyrite. The ratio of silver to gold is about 25 or 30 to 1.

SAN LORENZO (SAN ACACIA) DISTRICT

The San Lorenzo district is west of San Acacia and in the northern continuation of the Lemitar Mountains. Small showings of oxidized copper minerals occur in a wide brecciated fault zone in the volcanic rocks. Manganese ore[1] occurs in the vicinity of the contact between the volcanic rocks and the later Tertiary sandstones. The manganese ore occurs as replacement and cementing material in irregular bodies of andesite conglomerate, and in fissures in andesite.

SCHOLLE DISTRICT

The Scholle district is at the junction of Socorro, Torrance and Valencia counties and embraces parts of all three. The ore deposits are in the Abo sandstone and are similar to the general type of copper deposits in "Red Beds." The copper occurs as carbonates in the shale beds; as sulphides, chiefly chalcocite, associated with plant remains and fossil wood in arkose; and as nodules and lenses of sulphides which replace the cement and feldspar of the arkose. Silver is present in small amounts. In places the oxidized ores contain vanadium, probably as a copper vanadate.

This district produced a small tonnage of ore steadily from 1915 to 1919, but production since then has been desultory. The latest recorded production was for the year 1930. The approximate entire production of the district, all of which is credited to Torrance County in official reports, consists of 10,380 tons of

[1] Wells, E. H., op. cit., pp. 75-76.

ore carrying 1,006,068 pounds of copper, 7,872 ounces of silver, and $200 worth of gold, having a total value of $224,143. A negligible quantity of lead was reported in the shipments for 1917. Several small leaching plants were built in the district, but they were unsuccessful.

SOCORRO PEAK DISTRICT

Socorro Peak is approximately 4 miles west of Socorro. Silver ore was discovered in the district in 1867, and the period of greatest mining activity was from 1880 to 1895. A custom smelter was constructed at Socorro in 1881 and was dismantled about 20 years later. Some of the ore from the district was treated at a stamp mill in Socorro. The mines have been shut down since about 1900, except for sporadic small-scale operations. Production has been variously estimated at from $760,000 to $1,000,000.

Socorro Peak is composed mainly of volcanic rocks, chiefly rhyolite and trachyte and associated tuffs and breccias. A considerable thickness of Pennsylvanian strata is exposed on the eastern face of the mountain, and at one place in the sedimentary area is a small exposure of pre-Cambrian argillite. A long tunnel in the sedimentary area exposes a large mass of monzonite porphyry which, however, does not appear on the surface. The eastern face of the mountain is much faulted and fractured.

The principal ore deposits are narrow veins in the volcanic rocks. The ore consists of silver halides in a quartz-barite gangue. Only a trace of base-metal mineralization is present.

Weak, scattered mineralization occurs in the sedimentary area, chiefly along the major faults. It consists essentially of a small amount of galena in an abundant barite gangue. Manganese oxides occur in brecciated zones and fault fissures.

WATER CANYON (SILVER MOUNTAIN) DISTRICT[1]

The Water Canyon district adjoins the Magdalena district to the southeast. It is on the east side of the Magdalena Range. The rocks consist of the Lake Valley (Kelly) limestone (Mississippian), Magdalena formation (Pennsylvanian), basal pre-Cambrian argillite, and overlying Tertiary volcanic rocks. The formations are greatly faulted.

The most important ores of the district are in limestone and contain lead, copper and zinc accompanied by minor amounts of silver and locally gold. They occur most commonly as replacement bodies at intersections of fissures with certain favorable horizons in the Lake Valley limestone. The ore bodies are generally rather small, and only about 75 tons of ore has been shipped. Gold and silver veins have been prospected in the volcanic rocks.

[1] See also Magdalena Mountains manganese district.

TAOS COUNTY

Taos County is in central-northern New Mexico. It is south of the State of Colorado and lies between Rio Arriba County on the west and Colfax County on the east. Its area is 2,252 square miles.

The Rio Grande traverses the central part of the county from north to south. From the river westward the county is mainly a basalt-capped plateau. The eastern part of the county is occupied by the western slope of the Sangre de Cristo Mountains, which consist chiefly of pre-Cambrian granite and schist and Pennsylvanian limestone. A narrow alluvial area lies between this range and the basalt plateau to the west. The boundary between Taos and Colfax counties follows the crest of the range.

Mining districts are few in number. Lode deposits occur in the Sangre de Cristo Mountains and placer deposits in the gravel at the foot of these mountains. With the prominent exception of the molybdenum deposits in the Red River district, all the known deposits are of secondary importance. The gold, silver, copper and lead produced in Taos County from 1904 to 1923 had a value of only $30,399.

ANCHOR (LA BELLE) DISTRICT

The Anchor district is on the western slope of the Sangre de Cristo Mountains, about 8 miles northeast of Red River and 12 miles north of Elizabethtown. The deposits are oxidized auriferous pyrite-quartz veins in greatly decomposed monzonite and diorite porphyry. The veins are commonly narrow. Most of the original pyrite has been oxidized, and the resulting hematite and limonite inclose in a free state the gold originally contained in the pyrite. The district has been idle for many years.

PICURIS (COPPER HILL) DISTRICT

Picuris is 12 miles east-northeast from Embudo station on the Denver & Rio Grande Western railroad. The rocks of the district are metamorphosed pre-Cambrian sediments. The mineral deposits consist of veins of glassy quartz carrying copper and gold. Chalcocite is the principal sulphide, and tetrahedrite and argentite are said to occur. The ores are somewhat oxidized. Unsuccessful attempts at mining these deposits were made in 1900.

Wolframite[1] has been mined from near Penasco, a few miles south of Picuris, and wolframite with cuprotungstite (?) occurs near Rinconada.[2]

[1] Hess, F. L., Tungsten minerals and deposits: U. S. Geol. Survey Bull. 652, p. 28, 1917.
[2] See Rinconada district, Rio Arriba County.

RED RIVER DISTRICT

The Red River district includes a considerable area around the town of Red River on the western slope of the Sangre de Cristo Range. The town of Red River is 13 miles east of Questa and is at the confluence of several tributaries of Red River, a short stream that flows past Questa and discharges into the Rio Grande.

Prospecting in this district is said to have started in 1869, and gold was recovered from both lode and placer deposits. A smelter was built in 1879 at the site of Red River, but it operated only a short time. The total gold production of the district is not large. The important molybdenum deposits of the district were recognized about 1917. The Western Molybdenum Co. was organized to develop the deposits but did very little work and in 1918 relinquished its holdings to the R. & S. Molybdenum Mines Co. Production began on a small scale in the spring of 1919, the ore being treated at a remodeled gold mill nearby. In 1920 the mines were taken over by the Molybdenum Corporation of America, which was organized for this purpose. Operations continued intermittently on a small scale until a flotation mill was constructed in 1923; since then operations have been continuous. The mine normally produces about 40 tons of ore a day, much of which contains 5 to 6 per cent of molybdenum sulphide. About 89 per cent of the molybdenum sulphide of the crude ore is saved in the concentrate; this is shipped to the company's plant at Washington, Pa., where it is converted into ferromolybdenum and calcium molybdate. Up to January 1, 1931, the total production of molybdenum sulphide was approximately 5,000,000 pounds.

The rocks of the Red River district consist of intrusive porphyries, volcanic tuffs and flows and the underlying pre-Cambrian complex that forms the main Sangre de Cristo Range in this vicinity. The gold deposits of the district occur most commonly in the intrusive rocks but cut the later volcanic rocks in places. The veins are generally narrow and discontinuous and are variable in width and direction. Many of the veins contain abundant silicified and pyritized breccia fragments of country rock. Pyrite is the most abundant sulphide of the ore, but galena and sphalerite are common. Chalcopyrite and molybdenite occur in small amounts, and petzite (?) has been found at the Independence mine. The gangue minerals consist of quartz, calcite and fluorite, in various proportions. The ores are valued chiefly for their gold content, but in one or two of the deposits lead was the chief metal.

About midway between Red River and Questa a group of veins crop out in which molybdenite is the principal ore mineral.[1]

[1] Larsen, E. S. and Ross, C. S., The R. and S. Modybdenum mine, Taos County, New Mexico: Ec. Geol., vol. 15, pp. 567-573, 1920.
Carman, J. B., Mining methods of the Molybdenum Corporation of America at Questa, N. Mex.: U. S. Bur. Mines Inf. Cir. 6514, 1931.

These veins were known for many years before the molybdenum minerals were recognized, but the molybdenite was mistaken for graphite and the yellow molybdic ocher for sulphur. Development of these veins by the Molybdenum Corporation of America has shown the occurrence to be the second largest known molybdenum deposit in the United States.

The veins occur in eastward-trending sheeted zones several hundred feet wide in alaskite porphyry intrusive into granodiorite. No commercial veins have been found in the granodiorite, although small veins and stringers are common in that rock. The larger veins follow the stronger lines of shear and are joined together by a complex network of branching and intersecting veinlets and stringers. The veins consist of closely spaced branching fractures filled with ore. The dip of the different veins is 20° to 90° and averages about 60°. The average width as mined is between 12 and 18 inches. Some veins are up to 10 feet across, but in these wider veins the ore is confined to thin streaks near the walls, the rest of the vein being made up of altered country rock. Individual seams within the veins range from a fraction of an inch to 6 feet in thickness. Seams only a few inches thick can be mined profitably. Veinlets and films of ore penetrate the wall rock, but there is almost no replacement of wall rock by ore. The veins are usually 200 to 500 feet in length. The longest continuous vein that has been followed is about 1,400 feet long and extends for 400 feet down the dip. The veins are faulted by numerous, barren transverse fractures. Displacement is rarely more than 15 feet, but its direction and amount is so erratic that considerable difficulty is experienced in exploring the veins.

The mineralized zones contain a comparatively small proportion of vein filling, most of the zone being made up of sericitized alaskite porphyry between the branching ore-filled fractures. The vein filling consists mostly of quartz but contains a large proportion of molybdenite, some pyrite, and a little chalcopyrite, fluorite, apatite, biotite, rhodochrocite and calcite. Molybdenite is the only mineral of value. In the oxidized parts of the vein the molybdenite has been altered to yellow molybdic ocher. Owing to rapid erosion the oxidized zone seldom extends more than a few feet below the surface, and in places molybdenite occurs in the outcrops of the veins.

RIO GRANDE VALLEY[1]

Placer gold occurs here and there in the sand and gravel deposits of the Rio Grande valley in Taos County. These deposits occupy an area of several hundred square miles and are hundreds of feet thick in places. The most promising part probably begins near the mouth of Red River in the northern part of the county

[1] Wells, E. H., and Wootton, T. P., Gold mining and gold deposits in New Mexico: N. Mex. Sch. of Mines, State Bur. of Mines and Min. Res. Circular No. 5, p. 22, 1932.

and extends southward as far as Embudo in Rio Arriba County, a distance of about 40 miles. The Rio Grande flows in a moderately deep gorge for a considerable distance in the gravel area. The gravels have been derived from a number of mountainous areas within the Rio Grande drainage basin, in large part from the Sangre de Cristo Range of New Mexico and Colorado. The gold lode deposits of the New Mexico part of this range are relatively unimportant, and the rocks of most of the remainder of the upper part of the drainage basin give no evidence of primary gold mineralization necessary in order to supply gold to the gravels.

The placer deposits of this area consist of bench placers, river-bar placers and deep river placers. The bench deposits are the most extensive. Gold occurs in them but probably not in commercial amounts. Large areas of these deposits are capped by basalt, and basalt flows of unknown extent are interbedded with the gravels. The river-bar deposits are smaller than the bench deposits, but they have yielded nearly all the small amount of gold obtained. Several tests of the river gravels have been made, and it is said that gold in encouraging amounts was recovered, particularly from just above bedrock. The river gravels are of unknown thickness in most of the river channel, and bedrock is probably too deep in many places to be reached by dredging operations. They are of doubtful value.

TWINING (RIO HONDO) DISTRICT

The Twining district is 34 miles northeast of Barranca on the Denver & Rio Grande Western railroad, and about 15 miles northeast of Taos. The rocks of the district are pre-Cambrian granite and schist cut by prominent monzonite porphyry dikes.

The principal deposit of the district is in amphibolite and chloritic schist and contains disseminated pyrite, chalcopyrite and bornite. The ore is very low grade. A number of small veins close to the porphyry dikes are said to carry variously galena, stibnite, gold, chalcopyrite, sphalerite and molybdenite.

TORRANCE COUNTY

Torrance County includes an area of 3,330 square miles in central New Mexico. Known metallic mineralization is unimportant, and ore has been mined only in the Scholle district, which is partly in Socorro and Valencia counties. The production of this district from 1915 to 1930, chiefly copper, had a value of $224,143, all of which is credited to Torrance County.

SCHOLLE (CAROCITO) DISTRICT

This district is described under Socorro County.

UNION COUNTY

Union County, in the northeast corner of the State, is floored with Mesozoic and Tertiary strata and Tertiary and Quaternary lavas.[1] Dakota sandstone and Quaternary basalt predominate.

Indications of gold, silver, copper and lead are said to occur at a number of places, and gold has been mined near Folsom.[2] Deposits of copper have been prospected near Clayton.

VALENCIA COUNTY

Valencia County, in western New Mexico, extends from Bernalillo and Torrance counties westward to the Arizona line. Its area is 5,659 square miles. Most of the county is covered with Cretaceous strata, but there are large areas of Permian and Triassic "Red Beds" and Quaternary basalt.

The metalliferous deposits, in which gold and copper predominate, are generally unimportant. They occur chiefly in the Zuñi Mountains in the northern part of the county. Parts of the Scholle district, Socorro County, and of the Tijeras Canyon district, Bernalillo County, extend into Valencia County. Total production of the county, exclusive of that from the Scholle district, amounts to about $3,000.

HELL CANYON DISTRICT

See Tijeras Canyon district, Bernalillo County.

MANZANA DISTRICT

See Scholle district, Socorro County.

ZUÑI MOUNTAINS (COPPERTON, COPPER HILL, MONTEZUMA) DISTRICT

The Zuñi Mountains district comprises an area of about 70 square miles in the Zuñi Mountains and includes the sub-districts of Copperton, Copper Hill and Montezuma. The towns of Bluewater and Grant on the Atchison, Topeka & Santa Fe railway are about equidistant from Copperton, being 20 miles northeast and east respectively. A moderate amount of prospecting has been done in the district, but production has been negligible. A concentrating mill which was erected in the district to treat copper ores was destroyed by fire in 1927.

Pre-Cambrian granite, gneiss and schist crop out in the central part of the district and are nearly surrounded by upper Paleozoic and Mesozoic strata. The Abo (Permian) formation rests directly upon the pre-Cambrian rocks.[3]

Copper deposits occur in both the pre-Cambrian rocks and in the Abo "Red Beds." In the pre-Cambrian rocks the ore occurs chiefly along conspicuous shear zones in tourmaline granite and granite porphyry. The ore is irregularly distributed and here and there impregnates the wall rock. Some of the ore bodies are rather large. The ore minerals are malachite, azurite,

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[1] Darton, N. H., Geologic Map of New Mexico, U. S. Geol. Survey, 1928. Scale 1:500,000.
[2] Otero, M. A., Report of the Governor of New Mexico, p. 246, 1903.
[3] Darton, N. H., op. cit., (U. S. Geol. Survey Bull. 794) pp. 137-140 and Pl. 33.

a little chalcocite and a sparing amount of native copper and chalcopyrite. The ore assays about 2 to 6 per cent copper and carries gold and silver. Deposits of gold and limonite occur in the pre-Cambrian granitoid gneiss.

The deposits in the "Red Beds" are of the usual type associated with these rocks. Carbonaceous matter is present. The best ore seems to occur in shale.

PRODUCTION OF METALS IN NEW MEXICO

Summary of Production

Year	Gold[a] Ounces	Gold[a] Value	Silver[a] Ounces	Silver[a] Value	Copper Pounds	Copper Value	Lead Pounds	Lead Value	Zinc Pounds	Zinc Value	Iron Ore Long tons	Iron Ore Value	Manganese Ore[b] Long tons	Manganese Ore[b] Value	Manganiferous Ore[c] Long tons	Manganiferous Ore[c] Value	Molybdenum Pounds	Molybdenum Value	Tungsten Ore Short tons	Tungsten Ore Value	Totals
Prior to 1880[d]	749,000.00	$15,483,000	10,000,000	$12,500,000	30,000,000	$ 6,000,000	25,000,000	$ 1,500,000	—	$ —	—	$ —	—	$ —	—	$ —	—	$ —	—	$ —	$ 35,483,000
1880-1903[e]	654,717.80	13,534,219	23,781,517	22,328,441	49,366,527	7,217,170	157,017,326	6,227,212	3,011,297	142,760	410,000	585,000	—	—	—	—	—	—	—	—	50,034,802
1904-1930[f]	821,430.02	16,980,481	25,230,391	16,817,286	1,345,157,885	234,420,138	171,063,833	10,413,773	615,018,152	43,867,607	4,443,463	7,334,751	22,650	412,432	523,731	1,881,081	3,000,000	1,789,572	80	125,000	334,042,121
Totals	2,225,148.72	$45,997,700	59,011,908	$51,645,727	1,424,524,412	$247,637,308	353,081,159	$18,140,985	618,029,449	$44,010,367	4,853,463	$7,919,751	22,650	$412,432	523,731	$1,881,081	3,000,000	$1,789,572	80	$125,000	$419,559,923

Production, 1904-1930

Year	Gold Ounces	Gold Value	Silver Ounces	Silver Value	Copper Pounds	Copper Value	Lead Pounds	Lead Value	Zinc Pounds	Zinc Value	Iron Ore Long tons	Iron Ore Value	Manganese Ore Long tons	Manganese Ore Value	Manganiferous Ore Long tons	Manganiferous Ore Value	Molybdenum Pounds	Molybdenum Value	Tungsten Ore Short tons	Tungsten Ore Value	Totals
1904	18,476.00	$381,930	214,553	$124,441	4,972,170	$636,438	3,122,372	$134,288	13,493,835	$688,186	125,000	$(g)	—	$ —	—	$ —	—	$ —	—	$ —	$2,116,278
1905	15,359.58	317,510	369,192	225,207	6,126,025	965,650	1,510,209	70,980	15,142,254	803,393	114,000	(g)	—	—	—	—	—	—	—	—	2,505,750
1906	14,174.80	293,019	491,127	333,966	7,028,670	1,356,533	2,987,369	170,280	17,292,655	1,054,852	162,000	(g)	—	—	—	—	—	—	(g)	(g)	3,409,150
1907	15,962.88	329,982	705,544	465,659	10,990,015	2,198,003	3,309,681	201,924	750,085	44,255	193,000	(g)	—	—	7,000	(g)	—	—	(g)	4,320	3,453,143
1908	14,452.37	298,757	405,044	214,673	6,112,680	806,867	873,763	36,698	3,576,518	168,096	(g)	(g)	—	—	—	—	—	—	(g)	(g)	1,621,091
1909	11,585.33	239,491	397,783	206,847	5,393,146	701,109	5,029,767	216,280	13,085,945	706,641	(g)	(g)	—	—	—	—	—	—	—	—	2,165,368
1910	23,337.26	482,424	843,987	455,733	4,614,386	596,027	4,320,841	190,117	18,088,129	976,759	188,720	189,112	—	—	—	—	—	—	—	—	2,880,192
1911	36,900.84	762,808	1,354,540	717,906	4,057,040	507,130	2,966,222	133,480	10,237,175	583,519	145,195	146,401	—	—	—	—	—	—	—	—	2,851,244
1912	37,947.57	784,446	1,536,701	945,071	34,030,964	5,615,109	5,494,018	247,231	13,566,637	936,033	(g)	(g)	—	—	—	—	—	—	(g)	(g)	8,653,874
1913	42,663.17	881,926	1,631,273	985,299	56,308,706	8,727,850	3,946,364	173,640	16,523,161	925,207	164,085	148,405	—	—	—	—	—	—	(g)	(g)	11,844,007
1914	56,680.79	1,171,696	1,777,445	982,927	59,307,925	7,887,954	1,763,641	68,782	18,403,392	938,573	81,980	(g)	—	—	—	—	—	—	(g)	(g)	11,124,932
1915	70,680.96	1,461,105	2,005,531	1,016,804	76,788,366	13,437,964	4,542,361	213,491	25,404,064	3,150,104	34,806	54,197	—	—	—	—	—	—	45	70,934	19,404,599
1916	66,877.47	1,382,430	1,766,274	1,162,206	92,747,289	22,815,833	8,214,189	566,779	36,570,649	4,900,467	157,779	188,157	—	—	16,574	47,966	—	—	16	39,227	31,083,117
1917	51,478.64	1,064,158	1,394,365	1,148,937	105,563,000	28,820,064	9,108,904	783,357	30,200,000	3,080,400	231,604	381,275	2,503	54,143	15,000	(g)	—	—	(g)	(g)	35,372,854
1918	33,030.02	682,791	782,421	782,421	98,264,563	24,271,347	8,398,239	596,275	24,050,324	2,188,579	275,266	546,212	3,126	80,195	33,807	159,890	43,328	38,995	4	4,300	29,351,505
1919	31,717.36	655,656	837,418	937,908	51,150,541	9,514,000	2,386,513	152,935	7,594,644	554,409	224,553	506,538	—	—	16,620	75,367	1,113	1,370	—	—	12,398,233
1920	23,234.61	480,302	768,042	837,166	54,400,691	10,009,727	2,869,525	229,562	10,013,580	811,100	274,705	547,370	2,053	32,107	19,300	98,343	34,900	17,207	—	—	13,062,894
1921	9,521.26	196,822	571,399	571,939	14,267,338	1,840,487	673,601	30,537	228,000	11,400	110,523	244,284	—	—	200	(g)	—	—	—	—	2,896,170
1922	19,964.02	412,693	752,240	752,240	31,937,207	4,311,523	3,012,223	165,672	4,496,806	256,318	113,038	(g)	—	—	87,367	(g)	—	—	—	—	6,256,446
1923	26,689.12	551,713	747,127	612,644	61,356,802	9,019,450	3,832,427	268,270	16,496,000	1,121,728	205,218	(g)	179	3,693	6,759	17,398	22,667	(g)	—	—	12,064,896
1924	24,803.56	512,735	795,070	532,697	74,691,436	9,784,578	3,634,511	290,761	20,759,200	1,349,348	189,371	(g)	775	(g)	23,246	(g)	140,239	(g)	—	—	13,108,119
1925	26,561.40	549,073	785,124	510,176	76,427,825	10,852,751	6,420,060	558,545	18,492,300	1,405,416	172,959	(g)	1,688	(g)	40,848	153,251	332,298	(g)	—	—	14,647,211
1926	19,630.72	405,803	450,934	281,399	81,642,379	11,429,938	6,960,366	556,829	24,104,800	1,807,860	216,269	(g)	1,966	(g)	81,440	(g)	(g)	(g)	—	—	16,352,808
1927	29,241.37	604,433	890,083	504,677	74,251,863	9,726,994	16,052,355	1,011,330	59,603,000	3,814,592	214,747	(g)	2,190	37,237	87,334	(g)	(g)	(g)	—	—	16,662,312
1928	32,912.41	680,360	827,798	484,259	89,854,648	12,939,069	15,610,501	905,409	62,406,000	3,806,766	184,623	(g)	2,627	(g)	56,331	(g)	(g)	(g)	—	—	19,549,863
1929	35,176.46	727,162	1,121,646	597,784	97,717,262	17,198,238	22,260,811	1,402,431	68,910,000	4,548,060	171,565	(g)	2,969	50,173	67,558	(g)	(g)	(g)	—	—	25,386,848
1930	32,370.42	669,156	1,107,335	428,324	65,150,000	8,469,500	20,766,900	1,037,845	65,629,000	3,145,392	173,432	(g)	2,574	34,384	14,427	41,118	(g)	(g)	—	—	14,590,217
1904-1930	821,430.92	$16,980,481	25,230,391	$16,817,286	1,345,157,885	$234,420,138	171,063,833	$10,413,773	615,018,152	$43,867,607	4,443,463	$7,334,751	22,620[h]	$412,432	523,731[h]	$1,881,081	3,000,000	$1,789,572	80	$125,000	$334,042,121

[a] Includes placer production.

[b] 35% or more of manganese.

[c] 5% to 35% of manganese.

[d] Estimated; estimates based on all available information but no great accuracy is claimed for the resulting figures.

[e] Largely from official sources, but includes some estimates.

[f] Figures for gold, silver, copper, lead, and zinc from 1904 to 1930 are from the annual reports in Mineral Resources of the United States by Charles W. Henderson. Figures for other metals compiled from various sources, mostly from the Mineral Resources series.

[g] Accurate figures not available; an estimate has been included in the totals.

[h] These figures have been compiled from the Mineral Resources annual chapters on manganese and are probably minima. According to J. W. Furness (The manganese situation from a domestic standpoint: U. S. Bureau Mines Inf. Circ. No. 6034, April, 1927), maxima figures for manganese ore and manganiferous ore for New Mexico through 1925 are 11,422 and 237,283 long tons, respectively. This would make the production 23,748 and 543,373 long tons through 1930.

PART IV. ECONOMIC FEATURES OF NEW MEXICO METAL RESOURCES

PRODUCTION AND USES OF THE METALS

SUMMARY OF STATE PRODUCTION

Aside from minor production of the metals by the Indians and early Spaniards, the mining history of New Mexico may be said to have started about 1801, when the Santa Rita copper deposits in Grant County were first worked. It is reported that for a brief period early in the nineteenth century as much as 20,000 mule loads or about 4,000,000 pounds of copper was produced annually. This copper was transported to Mexico and used largely for coinage.

The next important development in the mineral industry was the discovery of gold at the Old Placers, Santa Fe County, in 1828. Lode gold deposits were discovered at Ortiz in 1833 and other placer deposits at the New Placers in 1839. There are no detailed statistics of this early gold production but it has been estimated at between $125,000 and $250,000 per annum for a considerable period of time.

The accompanying table is a record of metal production in New Mexico. In the summary at the top, the production of the metals is presented for three periods: prior to 1880, 1880 to 1903, and 1904 to 1930. The estimate of production prior to 1880 is of course highly conjectural and has been reached by consulting various sources.[1] The figures from 1880 to 1903 are thought to be nearly correct, since they were taken, for the most part, from official records. In 1904 the United States Geological Survey began to keep a detailed record of mine production of gold, silver, copper, lead and zinc by States, counties and districts. Since 1923 these records have been kept and published by the United States Bureau of Mines, and the statistics for New Mexico during the period 1904-1930 were taken from reports by that bureau.[2]

Although figures for gold, silver, copper, lead and zinc are fairly complete, especially for the period from 1904 to 1930, production figures for the other metals are to some extent estimates. In the table actual figures are given where available, but where no figures as to quantity or value of the metal produced have been found, an estimate has been included in the total. This

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[1] Lindgren, Waldemar, Graton, L. C., and Gordon, C. H., The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, 1910.
Mineral Resources of the United States (U. S. Geol. Survey and U. S. Bur. Mines), annual volumes.
The mineral industry, its statistics, technology, and trade. McGraw-Hill Book Co., Inc., annual volumes.
Jones, Fayette A., New Mexico mines and minerals, 1904.

[2] Henderson, Charles W., Gold, silver, copper, lead, and zinc in New Mexico and Texas in 1929: U. S. Bur. Mines Mineral Resources, 1929, pt. I, p. 730, 1931; idem, 1930, pt. I, p. 794, 1932.

method of reaching approximate totals has been found necessary due to the fact that statistics are not generally published by the Government unless there were for a particular year three or more producers of the metal in the State. In New Mexico there have been, as a rule, less than three producers of iron, manganese, molybdenum and tungsten ores.

Figure 1 is a graphical record of New Mexico's mineral production since 1902. The World War had a profound influence on the mineral industry of the State, and the total production reached a peak of over $43,000,000 in 1917. There was a considerable drop in production in 1918, a much greater drop in 1919, a brief recovery in 1920 and then all minerals responded to the world-wide slump of 1921. From 1921 until 1929 there was a steady and rapid increase in production of all the metals, followed by a sharp decline for 1930 under the influence of the current depression.

GOLD

USES

Gold is the standard of value. Its uses in coinage and in jewelry and other industrial arts are too well known to require comment. Very little gold is physically used in everyday business transactions, its chief function being as a reserve against which paper currency is issued and upon which international credit is based. Actual gold bullion is transferred in settlement of international debts. In 1928 new gold used in the arts and manufactures in the United States amounted to 68 per cent of the domestic production.[1]

PRODUCTION

Gold mining in New Mexico began in 1828 with the discovery of the Old Placers in the Ortiz Mountains. The Santa Rita mines were discovered many years earlier, but although these mines at present yield considerable gold as a minor constituent of the copper ore, it is doubtful if any appreciable amount was obtained from this ore prior to the steam-shovel operations of the Chino Copper Co. The earliest lode mining for gold began with the discovery of gold-quartz veins in the Ortiz Mountains in 1833.

At the present time nearly all the gold produced in New Mexico comes from base-metal ores. Practically all placer districts in the State sporadically yield small quantities of gold, but production from this source during recent years has been insignificant as compared to the total gold production. In the 15 year period from 1915 to 1929 inclusive, lode and placer mines produced 501,520 ounces of gold valued at $10,367,338. Of this amount 264,806 ounces, or 52.8 per cent, came from dry and siliceous gold, gold-silver and silver ores; 36.8 per cent from cop-

[1] U. S. Bur. Mines Mineral Resources, 1928, pt. 1, p. 874, 1931.

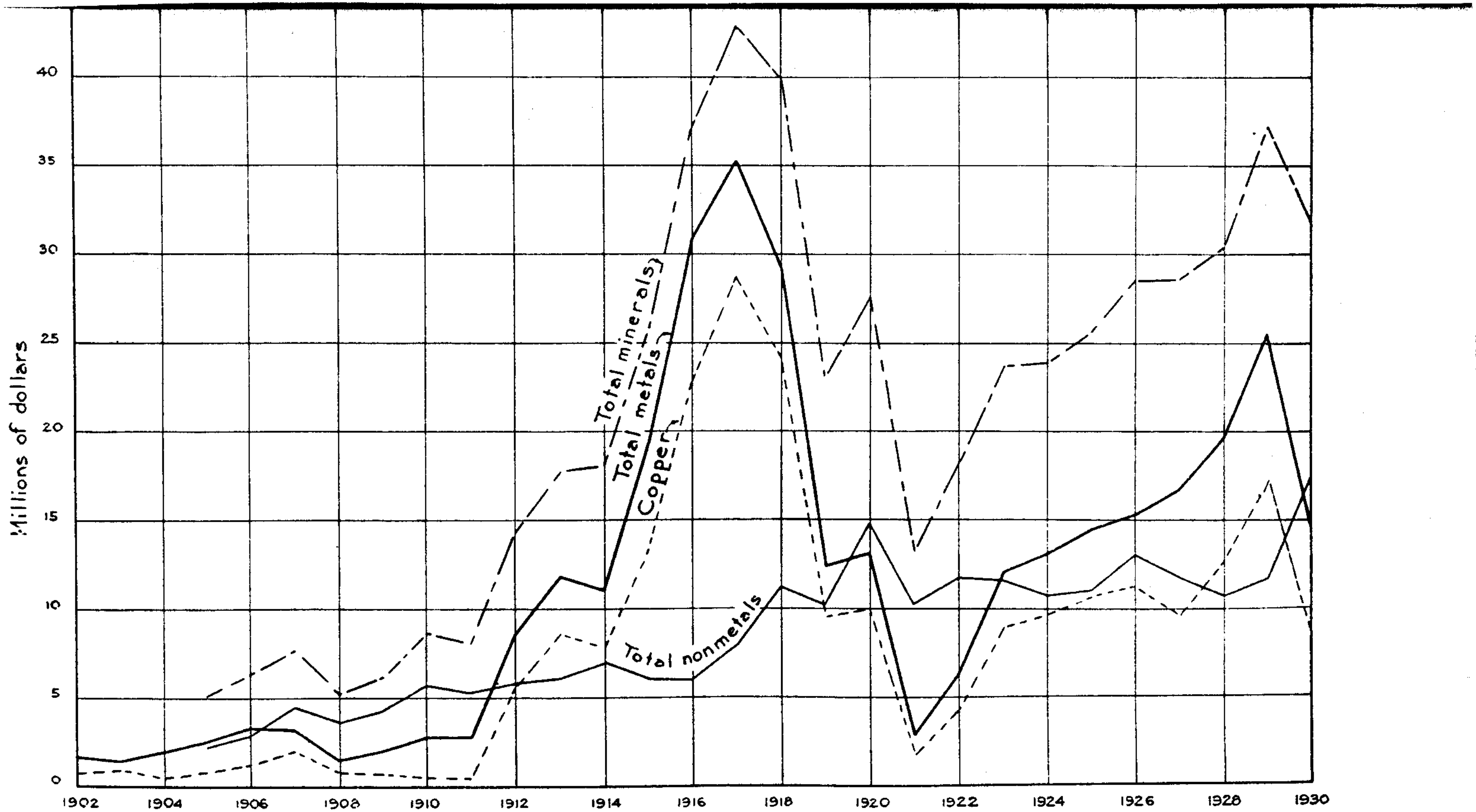

FIGURE 1. MINERAL PRODUCTION OF NEW MEXICO

per ores; 9.6 per cent from lead, lead-zinc and zinc ores; and the relatively unimportant quantity of 3,695 ounces or 0.7 per cent from placer mines. Similar calculations for the 1925-1929 period show that of 145,522 ounces of gold produced, dry and siliceous ores yielded 11.6 per cent, copper ores 56.6 per cent, lead and zinc ores 31.2 per cent, and placer workings only 0.5 per cent. For the years 1929 and 1930, copper ores yielded 51 per cent of the total gold production, lead and zinc ores 44 per cent, dry and siliceous ores 4 per cent and placer mines less than 1 per cent. It will be noted from these figures that the current production of gold is divided almost equally between copper and lead-zinc ores.

The total estimated production of gold from lodes and gravels in New Mexico to 1930 inclusive, representing 103 years of gold mining in the State, amounts to 2,225,149 ounces valued at $45,997,700. Statistics of total gold production have been kept since 1880, and it is interesting to note that for the 24-year period from 1880 to 1903 inclusive production was valued at $13,534,219 as compared with $16,980,481 for the 27-year period from 1904 to 1930. Production prior to 1880 was about 749,000 ounces, valued at $15,485,000.

Complete and accurate statistics of placer production have been kept since 1904. From 1904 to 1930 total gold production amounted to 821,431 ounces valued at $16,980,481, of which 24,988 ounces valued at $516,559 is placer production. Placer production to date may be estimated roughly at between $13,000,000 and $15,000,000, or about one-third of the total gold production of the State.

Figure 2 is a graph showing the production of gold in New Mexico from 1902 to 1930. The sudden rise in gold production in 1910 was due to increased activity in the Mogollon district. The beginning of important production from the Elizabethtown district and almost doubled production from Mogollon in 1911 were responsible for the continued sharp rise. In 1914 production from the Elizabethtown district exceeded the 1911 output by more than 100 per cent, and the Pinos Altos district also showed a large increase for that year. In 1915 an appreciable quantity of gold was produced from base-metal ores whose production rose sharply under the stimulus of war conditions. This, added to a further sharp increase from Elizabethtown, sent production for 1915 to a maximum of 70,680 ounces valued at $1,461,000; a figure which has never again been equaled.

Gold production in 1917 and 1918 was considerably less than in 1915 and 1916, the drop in output being due almost entirely to decreased activity in the Elizabethtown, Mogollon, San Pedro (New Placers), and Orogrande districts. Curtailment of operations at the Mogollon and Elizabethtown districts, due to impoverishment of reserves, coincided with the nation-wide post-war slump, and since then the gold output has reflected the base-

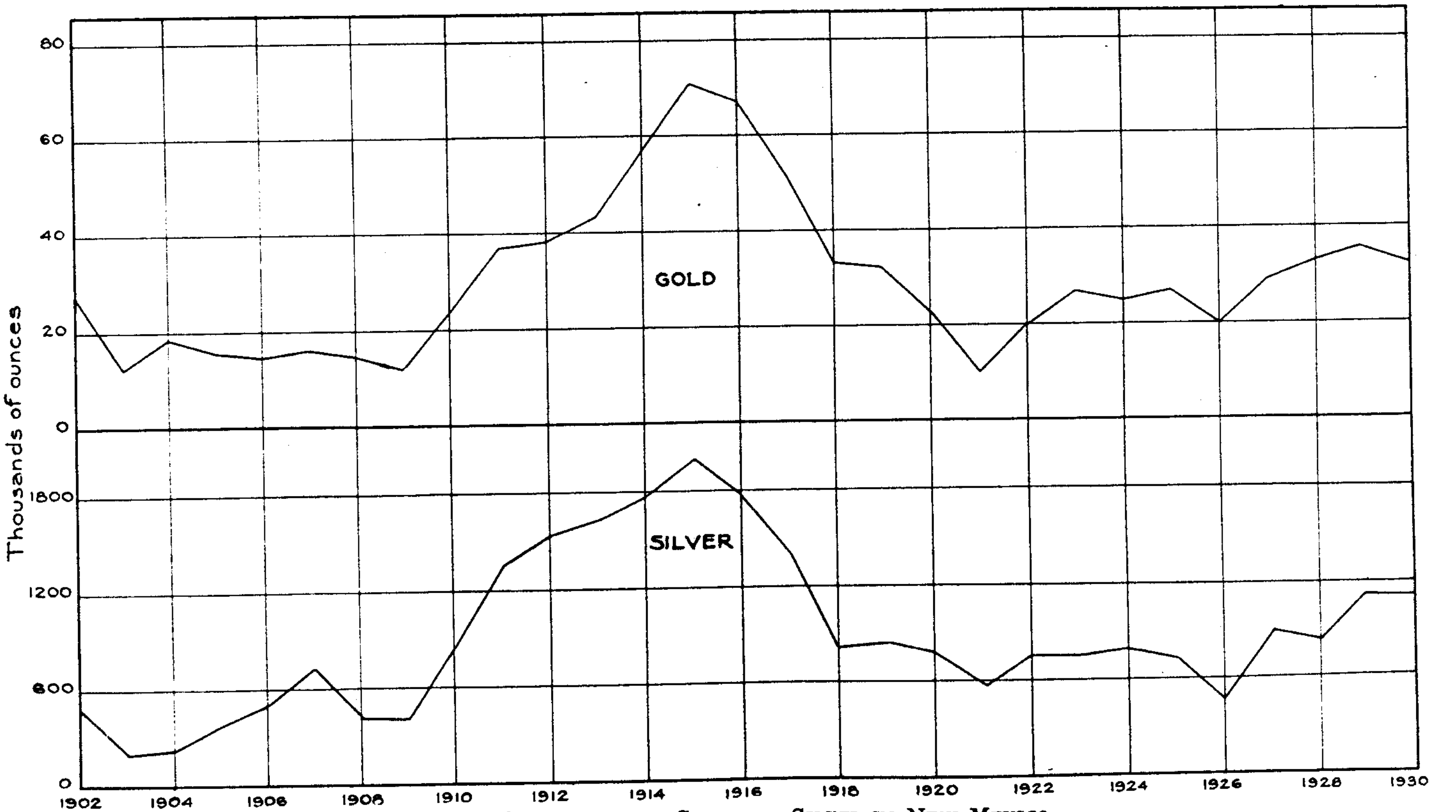

FIGURE 2. PRODUCTION OF GOLD AND SILVER IN NEW MEXICO

metal production. The Mogollon district shut down almost completely late in 1925, thus accounting for the sudden drop in 1926.

The Pecos mine of the American Metal Co. of New Mexico in San Miguel County began production in January, 1927, and although this is primarily a zinc mine it has been the largest single producer of gold in the State since then.

SILVER

USES

The principal uses of silver are in coins and as a medium for exchange in settlement of trade balances, and in jewelry, silverware and photographic film. The growth of the motion picture industry has greatly increased industrial consumption of silver. In 1928 total industrial consumption of new silver was 43 per cent of total domestic output.[1] The future status of silver as a coinage and exchange medium is very uncertain, owing largely to unsettled monetary and economic conditions in most of the leading countries of the world.

PRODUCTION

The beginning of silver mining in New Mexico coincides with that of gold mining, since the placers in the Ortiz Mountains carry a certain proportion of silver. In the period from 1904 to 1930, total production of silver amounted to 25,280,391 ounces valued at $16,817,286. Prior to 1904 production was valued at approximately $34,829,000, making the value of total production approximately $51,645,000.

Figure 2 shows graphically the production of silver since 1902. The output of this metal practically parallels that of gold; in general it shows the same highs and lows and the same degree of dependence on base-metal production. In 1930 lead-zinc ore[2] yielded 67.3 per cent of the total silver output, copper ore 20.6 per cent, dry and siliceous ore 10.10 per cent and lead ore 2.0 per cent. Placers yielded in that year only 18 ounces valued at $7.

COPPER

USES

The many industrial uses of copper are well known. Chief among them, in approximate order of importance, are the following: Electrical manufactures; electrical transmission, including telephone, telegraph, light and power; automobiles; building appliances, as shingles, pipe, etc.; miscellaneous; brass and other alloys; and coinage. Research is disclosing many new uses.

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[1] U. S. Bur. Mines Mineral Resources, 1928, pt. 1, p. 874, 1931.
[2] U. S. Bur. Mines Mineral Resources, 1930, pt. 1, p. 795, 1932.

PRODUCTION

The era of mining in New Mexico, exclusive of early Indian digging, began with the discovery of the Santa Rita copper deposits in 1800. Mining of these ores continued on a small scale until the steam-shovel operations of the Chino Copper Company began in 1911. The entire copper production of the Santa Rita district from its discovery to 1909 was about 100,000,000 pounds, or about as much as can be produced in one year with current methods of mining and milling. The gold ores of the Old Placers district, discovered in 1828, carried moderate quantities of copper, and almost each succeeding mineral discovery added somewhat to the copper resources of the State, since most of the metalliferous deposits of New Mexico contain recoverable copper.

Production of copper prior to 1904 is estimated at 79,367,000 pounds valued at $13,217,000. From 1904 to 1930 it amounted to 1,345,157,885 pounds valued at $234,420,138. Production for 1929 and 1930 was nearly 5 per cent of the United States production for the same period.

Figure 3 is a graphical record of copper production in New Mexico with an insert showing production at 10-year intervals. In the 8 years succeeding 1904, or until steam-shovel mining at Santa Rita became effective, the annual output amounted to approximately 6,160,000 pounds of copper of which Grant County produced about 75 per cent. Since then Grant County has averaged 85 per cent of the State's production. The sharp rise in production for 1912 was the result of the large-scale operations at Santa Rita, which became effective in that year. The State reached its maximum output in 1917 with 105,568,000 pounds. The Central district, in which the Chino mines are situated, showed a decreased production in 1918, but this was nearly offset by increased production from the Burro Mountains district which reached its peak in that year with about 17,000,000 pounds. The drop in production in the post-war period was decidedly abrupt, but the recovery from 1921 to 1924 was equally as rapid. The curve for the succeeding years is rather ragged but shows an average rise. Production in 1929, under the stimulus of high prices for the metal in the early part of the year, was only about 5 per cent less than at the peak of 1917, and probably would have been higher than that peak were it not for the great curtailment of operations throughout the industry in general from mid-year onward in response to the serious business decline throughout the world. Production dropped sharply in 1930, and statistics for 1931 and 1932 will undoubtedly indicate still greater decreases, owing to a continuation of the business depression. The price of copper declined to 4¾ cents a pound in 1932 as compared with an average of 18.1 cents a pound for 1929.

Copper accounts for about 70 per cent of the value of New Mexico's total metallic output.

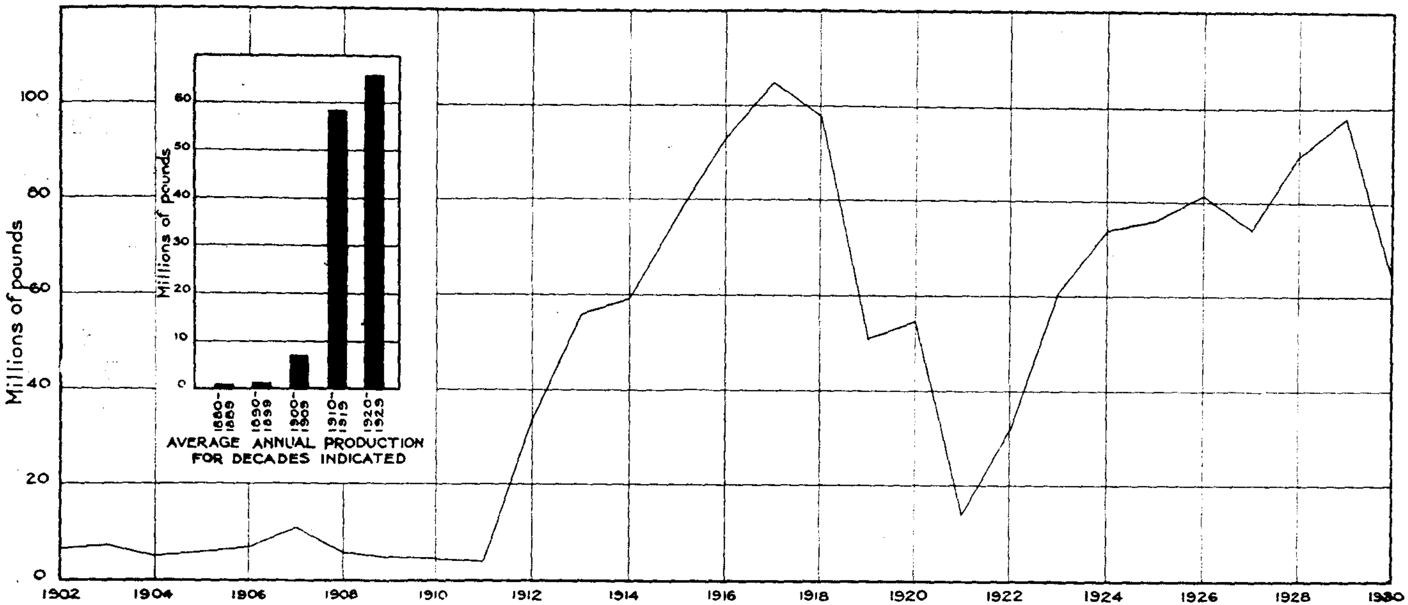

FIGURE 3. PRODUCTION OF COPPER IN NEW MEXICO

LEAD

USES

The chief uses of lead, named in the order of their relative importance are as follows: In storage batteries, in which more lead is used than in any other commodity or industry; in solution-resisting alloys, as cable covering and acid-chamber linings; in pigments; in pipe and other building accessories; and in ammunition, bearing-metal, type-metal and solder. There is a great variety of minor uses.

PRODUCTION

Most of the early lead production of New Mexico was from shallow oxidized ores in which the lead remains as residual material and forms a relatively high grade ore. These deposits were mined out in a few decades, and recent lead production has come chiefly from complex ores. In 1930, lead-zinc ores yielded 87.4 per cent of the total lead production, lead ores 7.6 per cent and zinc ores 3.4 per cent.[1]

From 1904 to 1930 New Mexico produced approximately 171,063,833 pounds of lead valued at $10,413,773. Total production through 1930 is estimated at about $18,141,000. Production for 1929 amounted to 22,260,811 pounds valued at $1,402,-431, which is the largest annual production to date. Figure 4 shows graphically the annual fluctuations since 1904. The insert shows production for 10-year periods since 1880.

Production from the Organ Mountains constituted an important part of the State's output in the early days, but no single one of the numerous lead camps of the State furnished an outstanding production. Lead reacted to the World War stimulus and to the post-war slump and recovery just as did the other metals. In 1927 the Pecos mine of the American Metal Co. of New Mexico in San Miguel County became the largest individual producer in the State in a district which previously had been of minor importance. The Ground Hog mine of the Asarco Mining Co. in Grant County began important production late in 1928, and its 1929 output of lead was in a large degree responsible for the sharp rise in the production curve for that year.

Lead represented about 7 per cent of the value of the total metal production of New Mexico in 1930.

[1] U. S. Bur. Mines Mineral Resources, 1930, pt. 1, pp. 795, 798, 1932.

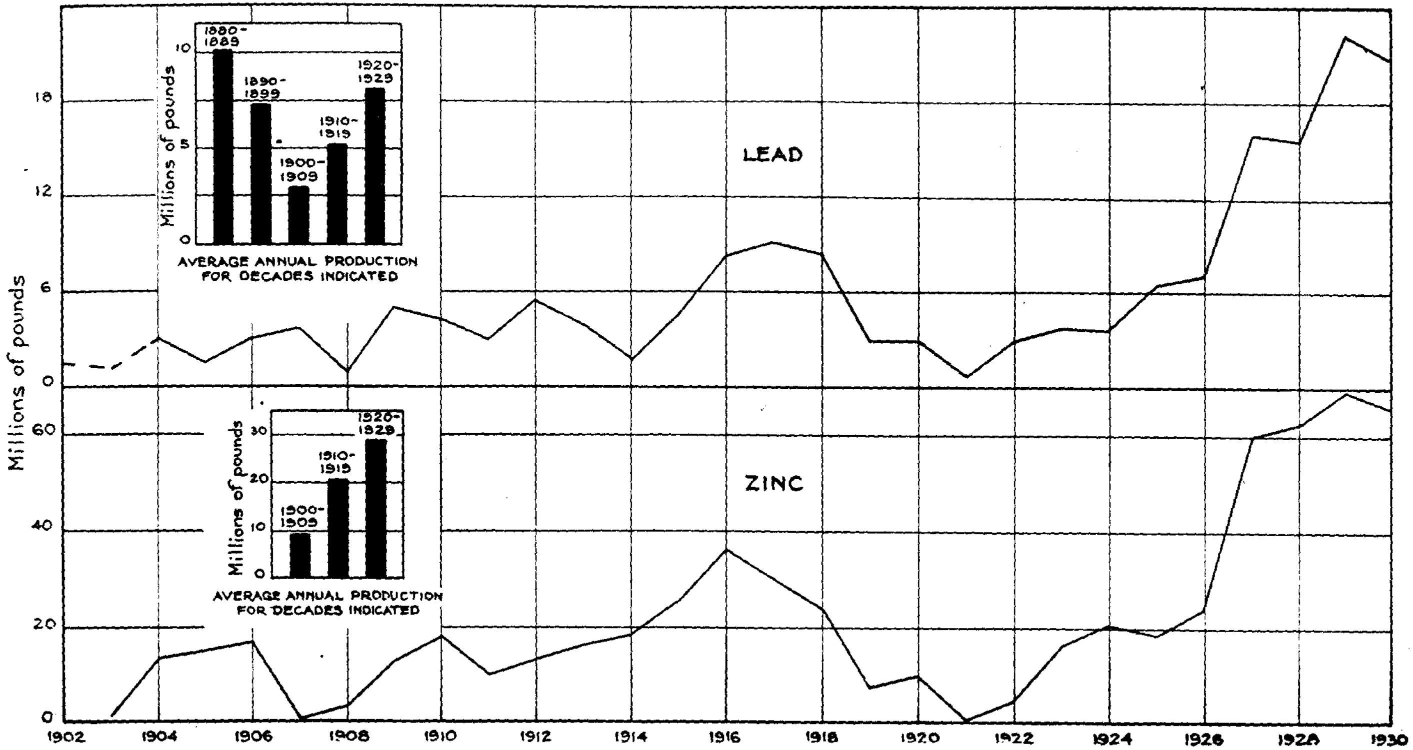

FIGURE 4. PRODUCTION OF LEAD AND ZINC IN NEW MEXICO

ZINC

USES

The outstanding uses of zinc are in the manufacture of zinc-coated (galvanized) products, in brass and other alloys, in the form of rolled sheets, and in the form of zinc oxide for pigments. Minor uses are numerous.

PRODUCTION

Although zinc ore was mined in the Hanover district as early as 1891, important production of zinc in New Mexico did not begin until discovery of zinc ores in the Magdalena district in 1903. Early production came from oxidized ores, but the sulphide ores were mined in increasing quantities as the flotation process of ore concentration was developed. Practically all the zinc now produced is contained in sulphide ores. In 1930 zinc accounted for nearly 22 per cent of the value of all metals produced and ranked next to copper in importance. In that year zinc production, in terms of pounds produced, exceeded copper production for the first time since the inauguration of steam-shovel mining at Santa Rita.

Figure 4 shows graphically the annual production of zinc in New Mexico. The total production of zinc is estimated at 618,000,000 pounds valued at about $44,000,000. Production for 1930 was 65,529,000 pounds valued at $3,145,392.

Up to 1912 the Magdalena district produced annually well over 90 per cent of the zinc output of New Mexico. In 1910 the Hanover mine of the Empire Zinc Co. yielded a considerable production, which accounts for the rise shown in the graph for that year. In 1911 Hanover production dropped to about one-fourth of that of the preceding year but rose sharply the following year, and this mine has since continued to be a major producer.

The war period and post-war slump affected zinc as they did the other metals. Production from the Magdalena district dropped in 1928 and has since remained at a small figure, but the loss has been considerably more than offset by production from the Pecos mine. Development of the Ground Hog mine was responsible for the further rise in production for 1928 and 1929.

IRON

USES

The uses of iron are too well known to require any particular comment. It is the most common and most widely used of all the metals. It is utilized chiefly as cast iron, wrought iron and steel, and also in paints and chemicals.

PRODUCTION

New Mexico has iron ore reserves of considerable magnitude. Most of the deposits consist of magnetite and hematite and are of the contact-metamorphic type. Some of the most important deposits are in the vicinity of Fierro, Grant County; near Fairview, Sierra County; and at Jones Camp, eastern Socorro County. The Fierro deposits are the only ones that have yielded an important production. Nearly 175,000 long tons of iron ore was shipped from these deposits in 1930 by the Hanover Bessemer Iron & Copper Co. Manganiferous iron ore has been produced from the deposits at Boston Hill near Silver City, Grant County.

The earliest statistical record of iron-ore production in New Mexico is for 1891. It is estimated that total production through 1930 amounts to approximately 4,853,000 long tons of ore, valued at $7,920,000.

MANGANESE

USES[1]

In general, the uses of manganese may be classified as "chemical" and "metallurgical," and the ores are classified as being of "chemical" or "metallurgical" grade according to the uses to which they can be put.

Metallurgical uses consume by far the greater proportion of manganese. Manganese is practically indispensable in steel smelting where it is used in the form of an alloy, usually spiegeleisen and ferromanganese. Spiegeleisen consists approximately of 20 per cent manganese, 75 per cent iron and 5 per cent carbon. Ordinary ferromanganese consists of 80 per cent manganese, 12 per cent iron and 6 per cent carbon. Silicomanganese and silicospiegel are used for certain grades of steel. Ferruginous manganese ore (10 to 35 per cent manganese) and manganiferous iron ore (5 to 10 per cent manganese) are used mainly in the manufacture of low-grade manganese pig iron.

Smaller amounts of manganese are used in the manufacture of such alloys as manganese bronzes, which consist of manganese, aluminum, zinc and copper or tin. Occasionally manganese ore is used as a flux in smelting silver ores, particularly when the two occur together, as at the Lake Valley district, Sierra County.

The principal use of manganese in the chemical industries is as a depolarizer in dry batteries. It is also used as a decolorizer of glass; in coloring glass, pottery, tile, and bricks; as a drier in varnishes and paints; and in the preparation of oxygen, chlorine, bromine, disinfectants and other chemicals and drugs. Recent research work has indicated that manganese may be of value in fertilizers.[2]

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[1] Furness, J. W., The marketing of manganese ore: Bureau of Foreign and Domestic Commerce, Trade Inf. Bull. 599, 1929.

[2] American Fertilizer, vol. 71, pp. 33-35, 1929.
U. S. Bur. Mines Mineral Resources, 1927, pt. 1, p. 165, 1930.

PRODUCTION

Very little manganese was produced in New Mexico prior to the World War. The high price that prevailed during the war period led to the working of numerous deposits, but none of these developed into large mines.

An important manganese deposit has been developed in the Little Florida Mountains, Luna County, and in recent years it has furnished most of the manganese production of New Mexico. Since 1925 this district has yielded about 13,000 long tons of high-grade ore and concentrates. Large deposits of manganiferous iron ore occur at Boston Hill near Silver City, Grant County. There are numerous other deposits in the State which in the aggregate contain appreciable reserves, but which can operate only under especially favorable conditions.

To 1930 inclusive, New Mexico produced 22,650 long tons of manganese ore containing 35 per cent or more of manganese, and 523,731 long tons of manganiferous ore containing 5 to 35 per cent of manganese which was mostly of lower grades. For 1929 three producers shipped 2,969 long tons of ore which averaged 45.89 per cent of manganese,[1] and was valued at $50,173. This ore was produced in Luna and Grant counties. In that year, 67,558 long tons of manganiferous iron ore containing about 13 per cent of manganese and 35 per cent of iron was shipped from the Boston Hill deposits.

MOLYBDENUM

USES

The principal use of molybdenum is as a constituent of alloy steels. For this purpose it is commonly used with other alloying metals such as chromium, nickel or manganese. Molybdenum is also used in cast iron, and this use is said to offer greater possibilities than its use in steel.

The electrical and radio industries are using increasing amounts of pure molybdenum as a support for filaments in lamps and tubes. Considerable molybdenum is used in the chemical industry, particularly in dyes and inks.

PRODUCTION

Important deposits of molybdenum ore occur in the Red River distict near Questa, Taos County. They are owned by the Molybdenum Corporation of America. This is the second largest molybdenum mine in the United States, and as a result of its operation New Mexico ranks second among the states in molybdenum production. The output of these deposits has an annual value of several hundred thousand dollars.

Small quantities of molybdenum ore have also been mined near Las Vegas, San Miguel County. At one time molybdenum was produced in the Organ district from wulfenite, but practi-

[1] The manganese industry in 1929: U. S. Dept. of Commerce, press release, May 27, 1930.

cally all production since 1919 has come from the Red River district.

Since production comes practically from only one source, it is impossible to give exact statistics. It is estimated that the total New Mexico production to Jan. 1, 1931, amounted to a little over 5,000,000 pounds of molybdenum sulphide (MoS_2), containing approximately 3,000,000 pounds of molydenum.

TUNGSTEN[1]

USES

The steel industry consumes more than 95 per cent of tungsten production in the manufacture of high-speed steels. The tungsten is used as ferrotungsten and tungsten powder. A secondary but very important use is as a filament in incandescent electric bulbs.

PRODUCTION

Some years ago there was a small intermittent production of tungsten ore from a number of places in New Mexico, chiefly from the White Oaks district, Lincoln County; the Picuris district, Taos County; and near Gage, Luna County. No production has been recorded since 1918. It is estimated that about 80 tons of tungsten ore and concentrates with an average content of 60 per cent of WO_3 and worth approximately $125,000 has been produced in New Mexico.

ARSENIC

A car of arsenic ore was shipped from the Hachita Mountains in 1924 to the Chipman Chemical Company's plant near San Francisco. In general, the by-product production by copper smelters is ample for industrial demands. Arsenic is used extensively in the manufacture of glass, as an insecticide and as a weed killer.

BISMUTH

A small amount of bismuth ore has been marketed from a prospect in Grandview Canyon in the San Andres Mountains. Most of it was sold as museum specimens. Bismuth was recovered from one shipment of ore from the Apache No. 2 district, Hidalgo County. It is produced in the United States chiefly as a by-product in the refining of lead and tin bullion, part of which is of foreign origin. Bismuth is used as a component of low melting-point alloys and in medicines.

NICKEL AND COBALT

Nickel and cobalt occur in the silver ores of the Black Hawk district, Grant County, but apparently not in commercial quan-

[1] Furness, J. W., The marketing of tungsten ores and concentrates: U. S. Bureau of Foreign & Domestic Commerce, Trade Inf. Bull. 643, 1929.

tities. Cobalt is used chiefly in high-speed tool steels and as a blue coloring matter for glass and ceramic ware. Nickel is used chiefly in making nickel-steel and nickel plate.

TANTALUM

A few hundred pounds of columbite, from which the rare metal tantalum is produced, was shipped from Las Tablas, Rio Arriba County, in 1931. Tantalum is used largely in the manufacture of radio and power tubes. Increasing quantities are being used as an acid-resistant in place of platinum, and there are several miscellaneous uses.

TELLURIUM

Tellurium is a by-product of the electrolytic refining of copper and doubtless has been extracted from the tellurium-bearing ores of New Mexico. The known uses for tellurium are insignificant. It is used chiefly in experimental work, but has found a small commercial application in silver electroplating, in the wireless industry and in medicine. The discovery that diethyl telluride is beneficial in motor gasoline led to the development of the widely used "ethyl" gasoline, in which lead tetraethyl, a cheaper and more abundant compound, is used.

TIN

The tin deposits of New Mexico are of unproved value and have never been worked. Tin is used principally as a coating on other metals to make tin plate, as in tin cans. It is also used extensively in solder, babbit and other anti-friction alloys, in bronze and as foil.

URANIUM AND RADIUM

The uranium deposits in the White Signal district, Grant County, have been commercialized to a slight extent, but no production figures are available. Uranium minerals are valuable chiefly for their radium content. The ores of the White Signal district have been used in drinking and bathing waters and in the manufacture of toothpaste and salves and other medicaments in the belief that the radium emanations have a general medicinal value. Uranium has been alloyed with metals for specific purposes, and uranium salts are used in glass and pottery coloring.

VANADIUM

Vanadium minerals occur at a number of places and locally in appreciable quantities. The only recorded production is a lot of 15 tons which was shipped to Germany in 1911 from the Lucky Bill mine near Vanadium, Grant County. This ore assayed 9.16 per cent vanadium pentoxide and returned $56 per ton f.o.b. Bayard, New Mexico.[1] Vanadium is used for manufacturing steel of unusual toughness and torsional strength.

MARKETING OF ORES AND CONCENTRATES

GENERAL FEATURES

Where and how ores and concentrates may be sold, and the sort of contract that will govern the sale are obviously important considerations to the miner. It often happens that one purchaser may be particularly desirous of a certain class of ore and be willing to pay a premium for it, whereas a neighboring smelter may penalize the same ore. Under certain conditions a smelter may penalize one constituent of an ore or concentrate and pay a premium for some other, and the miner may be able to make a considerable difference in the net return by preparing his ore to fit such special conditions. It is generally unwise to include with good ore a batch of poor ore that cannot pay its own way, since the increased smelter charges on the resulting lower grade material and the additional freight are likely to more than offset the value of the additional metal paid for.

The following pages describe the features pertaining to the sale of ores and concentrates of the different metals found in New Mexico. The marketing of practically all ores and economic minerals is discussed in considerable detail in "Marketing of Metals and Minerals"[2] which should be consulted by those particularly interested in this subject.

DEFINITIONS

New York Quotation.—Average price of the metals for the week ending with Wednesday, as published by the Engineering & Mining Journal.

Market Price or Quotation.—Same as "New York quotation."

Schedule.—That part of the contract dealing with the factors controlling the money due the seller.

Settlement Sheet.—The proceeds due the seller on any sale of ore or concentrate are computed upon a standard form known as a "settlement sheet" upon which is entered each item necessary for the computation. The last item is "net proceeds" or "net payment" and is the amount due the seller on the transaction.

Ton, Short.—2,000 pounds. Unless otherwise specified, the word "ton" refers to short ton.

Ton, Long.—2,240 pounds.

Unit.—Equivalent to 1 per cent of a ton.

GOLD AND SILVER BULLION

The only procedure necessary to sell gold or gold-silver bullion is to submit the bullion, pure or impure, to the nearest Government mint or assay office, where the metal will be assayed and settlement made. Gold is paid for at the rate of $20.67+ per troy ounce pure (1000 fine) and silver at the New York market price for the day prior to that on which the deposit is received. Base

[1] Larsh, P. A., Lucky Bill vanadium mine: Eng. and Min. Jour., vol. 96, pp. 1103-1104, 1913.

[2] Edited by J. E. Spurr and F. E. Wormser. McGraw-Hill Book Co., Inc., New York City, 1925. Price $6.00. Can be consulted at any technical and many public libraries.

metal content is not paid for. The Treasury Department will pay for bullion by a draft on the Treasurer of the United States, in gold coin, in gold certificates or in refined gold bars, as preferred by the seller. Placer gold in small quantities can generally be exchanged for merchandise at local stores and sometimes may be sold for cash, though at a reduced price.

Gold and silver can be sold to the Government as bars, lumps, grains or dust, free, or nearly so, from earth and stone. Gold and silver recovered by amalgamation will not be accepted unless the mercury has been expelled, and cyanide sludge must first be fluxed and smelted. Silver free from gold is not normally accepted for purchase, nor will government agencies purchase gold or silver bullion which contains much lead. Copper bullion will be purchased providing it contains at least one-fifth its weight in gold and silver, and providing further that the value of the gold and silver is not less than $100. A smelting charge is made on all bullion deposits.

The Treasury Department maintains assay offices at New York City; Helena, Mont.; Deadwood, S. Dak.; Salt Lake City, Utah; Seattle, Wash.; New Orleans, La.; and Carson City, Nevada. Mints are located at Philadelphia, Denver and San Francisco. All consignments are forwarded at the risk of the sender, and they should therefore be shipped in the quickest and safest manner, usually prepaid express or insured parcel post. Government regulations require that all deposits must be delivered free of all transportation charges.

Treasury Department Circular, Form 506, United States Mint service, entitled "Abstract of Regulations Covering the Receipt of Gold Bullion for Coinage, or for Conversion into Fine, Standard, or Unparted Bars, at the United States Mints and Assay Offices," contains detailed information on this subject. It is available at the different government mints and assay offices and should be obtained by those who are marketing gold or gold-silver bullion.

Since there are no operating smelters in New Mexico, the above simplicity in marketing gold and silver refers, so far as the miner in New Mexico is concerned, only to placer metal and metal extracted as such from the ore. Gold and silver in ore is sold to the smelter with the other metals included in the ore.

SMELTER CONTRACTS FOR GOLD, SILVER, COPPER AND LEAD ORES

A satisfactory furnace charge requires essentially lime, iron and silica, but most ores do not contain these constituents in the proper proportions. Inasmuch as it is obviously uneconomical to supply any necessary constituent by adding barren rock, the practical procedure used by the smelter is to accumulate stock piles of ores from different mines and districts and to mix these ores in the proper proportions as needed. The custom smelter is therefore in the market for all classes of ores. A smelter treating ore from its own mines, on the other hand, is in the market only for certain classes and may pay more for these than the custom smelter may pay.

The difference between the gross value of the marketable constituents of the ore as determined by assay and the amount paid the miner is made up of two elements: smelting charges and marketing charges. The latter are definite charges against the ore that, for convenience, are paid by the smelter on behalf of the miner and charged against him on the settlement sheet. They may include: (a) freight on ore from mine to smelter, (b) demurrage, (c) extra sampling costs and umpire assaying, and (d) freight on metal from smelter to refinery.

Smelting charges may be classified under three heads:

1. Nominal treatment charge.
2. Deductions from assay content or from market quotations of the salable metals.
3. Penalties imposed because of the presence of undesirable constituents or other objectionable features of the ore.

The different smelting charges should be such that the smelter receives a margin of profit proportionate to the quantity of metals contained and to the expense of treatment and marketing. Rates adjusted in this way yield the smelter a small margin of profit on low grade ores and a proportionally higher profit on high grade ores.

Typical ores may be divided into the following classes, for each of which a different schedule of charges applies:

1. Lead ore; rich in lead, low in copper.
2. Copper ore; rich in copper, low in lead.
3. Dry siliceous ore; valuable for gold and silver, but low in lead and copper.

NOMINAL TREATMENT CHARGE

The nominal or base treatment charge is supposed to represent those costs that are properly distributed on a tonnage basis; that is, it includes the normal operating expense entailed in treating a ton of material. Some contracts call for a flat charge, while others provide a fluctuating charge in proportion to the metal contained, depending upon the requirements of the smelter. The following are taken from schedules on New Mexico ores:

(A) A flat rate of $2.50 per ton.

(B) A charge of $3.50 per ton on ore containing 5 per cent of copper or less, plus 20 cents per unit above 5 per cent, but not to exceed a maximum treatment charge of $5.00 per ton.

(C) A charge of $3.50 per ton on ore containing 25 per cent of lead as determined by wet assay, with an additional charge of 5 cents per unit under 25 per cent and a credit of 5 cents per unit above 25 per cent.

(D) A charge of \$3.50 per ton, providing the sum paid for gold, silver and copper does not exceed \$8.00 per ton, plus \$0.50 per ton for each dollar above that amount, the total treatment charge not to exceed \$5.50 per ton.

DEDUCTIONS ON CONTENT AND QUOTATION

In a general way, deductions from metal content serve to cover metallurgical losses in treating the ore and in refining the bullion. The deductions made from the metal quotations are to cover certain costs directly proportionate to the quantity of metal contained, such as costs of refining, marketing and shipping of bullion, and interest on the capital involved. Deductions are higher than actual losses and costs in order to provide the smelter's margin of profit.

Gold and Silver.—The minimum amount of gold paid for varies from 0.01 to 0.05 oz. per ton. Between 95 and 100 per cent of the assay content is usually paid for, if the quantity contained is above the minimum, at a price between \$19 and \$20 per ounce, as compared with the standard mint value of \$20.67+.

The minimum amount of silver paid for is usually 1 ounce per ton, though it may be as low as 0.5 oz. Generally 95 per cent, though sometimes 90 or 100 per cent of the content is paid for. Deductions from the market price range from nothing to 3.5 cents per ounce.

Gold and silver are settled for on the above basis whether the ore be classed as lead, copper or dry.

Lead.—The settlements for lead vary widely. The minimum content is generally 5 per cent as determined by dry or fire assay. One smelter handling ore from New Mexico places the minimum of 3.5 per cent. "Dry assay" is usually the "wet assay" minus an arbitrary deduction of 1.5 per cent. Sometimes the lead content is determined by a wet analysis of the button obtained in a fire assay. The purpose of paying on the assay obtained in this manner is to compensate for an assumed average metallurgical loss of approximately 30 pounds per ton of ore. A typical contract specifies payment "for 90 per cent of the dry assay (wet assay less 1.5 units)" at the average New York quotation for the week prior to sampling at the smelter, less 1.5 cents per pound. One contract specifies an additional deduction of 0.4 of a pound of lead for each pound of copper paid for.

If the lead content of an ore is less than the minimum provided it is considered a dry ore; that is, it does not supply its proportion of the lead required in the furnace and the lead is therefore not paid for. Payment is not made for the lead in ores smelted in copper furnaces.

Copper.—Deductions on copper ore vary. The following are taken from typical schedules:

(A) Deduct 8 pounds per ton of ore or concentrate and pay for 95 per cent of the remainder.

(B) Pay for 90 per cent of the copper content with a minimum deduction of 7 pounds of copper per ton of ore.

(C) When the wet assay is 5 per cent and under, deduct 10 pounds per ton and pay for the entire remainder. When the wet assay is over 5 per cent, pay for 90 per cent of the copper contained.

Deductions from market price for copper vary from 2.25 cents per pound on a siliceous ore to 3.75 cents per pound on a lead ore.

PENALTIES AND PREMIUMS

In any particular contract the payments and deductions for fluxing elements, such as iron, manganese, lime and insoluble or silica, reflect the metallurgical conditions confronting operations at the smelter concerned. The charges made for impurities such as arsenic, antimony, tin and bismuth are generally in line with penalties imposed on the smelter by the refinery. Because of differences in refining operations on lead and copper bullion, penalties imposed by lead smelters are generally more severe than those imposed by copper smelters.

Silica.—Generally a penalty of 10 or 12 cents per unit for total content of silica or insoluble is imposed, in which event iron and manganese are paid for at 5 or 6 cents per unit. Where siliceous ores are at a premium, a deficiency of silica is penalized rather than an excess. Sometimes the silica penalty depends upon the proportion of silica to iron plus manganese. For example, a certain contract provides for a penalty on silica less than 60 per cent excess over iron plus manganese. Another penalizes silica in excess of iron plus manganese.

Lime.—In one open contract from a smelter buying New Mexico ore, available lime is paid for at 8 cents per unit if the amount present exceeds 2 per cent. An actual sale of ore to a second smelter likewise commanded a premium of 8 cents per unit.

Iron and Manganese.—See under "Silica."

Sulphur.—Sulphur is commonly a source of trouble in the lead blast furnace. This is particularly true when the charge is high in zinc. Although the copper smelter is likely to ignore the sulphur content, the lead smelter penalizes this element above a certain generally low maximum. In one contract, only 1 per cent is allowed free and the excess penalized at 20 cents per unit.

Zinc.—Not only is zinc in copper and lead ores lost in smelting operations, but it adds to the difficulties of treatment and is therefore penalized. Typical zinc penalties imposed by purchasers of ore from New Mexico are as follows: 30 cents per unit in excess of 5 per cent (siliceous ore to a copper smelter); 25 cents per unit in excess of 8 per cent (copper and siliceous ores to a copper smelter) ; 25 cents per unit in excess of 5 per per cent (lead ore).

Arsenic, Antimony, Bismuth and Tin.—Arsenic is an objectionable constituent in the smelting charge. It has an affinity for iron with which it forms speiss, a substance that has a high fusing point and that accumulates in the furnace. Arsenic, as well as the other impurities, also gets into the bullion and must be removed in refining.

Penalties for these impurities vary widely. In some contracts each impurity bears its own penalty. In others the combined content of these elements or different combinations of them are penalized at a single rate. Typical penalties are as follows:

(A) Allow free 1 per cent of arsenic, antimony and bismuth combined. If the combined content is over 1 per cent, charge for all at $1.00 per unit.

(B) Allow 2 per cent of arsenic free and charge for excess at $1.00 per unit. Allow free 0.5 per cent of antimony and tin combined and charge for excess at $1.50 per unit. Allow free an amount of bismuth equal to 0.1 per cent of the wet lead contained and charge for excess at 50 cents per pound.

(C) Allow free 3 per cent of arsenic, antimony and bismuth combined and charge for excess at 30 cents per unit.

Cobalt and Nickel.—Cobalt and nickel are penalized commonly at the rate of $2 to $3 per unit.

Moisture.—Many schedules provide a penalty for moisture. One contract allows 12 per cent free and charges 20 cents for each per cent in excess. Manifestly this charge seldom applies except to flotation concentrates.

Other Penalties.—Other special penalties are sometimes charged. For example, one smelter charges 50 cents per ton to cover the extra expense involved in handling shipments received in sacks. Another makes a special sampling charge on shipments of less than a certain minimum number of tons. Some copper smelters penalize a copper deficiency. Concentrates generally carry a special sintering charge.

OTHER CLAUSES

Force Majeure Clause.—All contracts carry a clause governing cancellation of the terms of the contract. The following extracts are from typical contracts issued by smelters purchasing New Mexico ores:

(A) These quotations may be cancelled by us without notice in case of strikes, fires, or other disturbances to operations beyond our control.

(B) This agreement shall be subject to cancellation on 60 days written notice by either party, with the understanding that should conditions require curtailment or cessation of operations of either party all shipments shall be cut off by giving 10 days notice in writing.

Duration of Contract.—The life of contracts differs. It may cover only a single shipment or may extend over a period of months or years.

Delivery.—All quotations are f.o.b. buyer's plant. Ordinarily the buyer pays the freight upon receipt of the ore and deducts the amount from the proceeds due the shipper as computed on the settlement sheet.

Weighing and Sampling.—Weighing and sampling are generally done at the buyer's plant and at his expense, subject to supervision by the shipper or his representative. Settlement is made on the weights and samples so taken, and generally any protest as to the accuracy of sampling or weighing must be made within 24 hours. Some smelters reserve the right to dispose of the ore for smelting when the initial sample is taken.

Assaying.—Three finished pulp samples are prepared from each lot of ore, a lot generally consisting of from one to eight cars of ore. Buyer and seller each have the necessary assays made, and these should check within certain specified limits. The buyer's assays control if no protest is made. Upon large shipments the average of the two assays is generally accepted for settlement if these assays agree within the specified limits. If they do not agree a re-assay is arranged, and if the results still fail to agree the third pulp sample is assayed by an umpire mutually agreed upon. In some cases the umpire results are final. In other cases either the middle assay or the one nearest the umpire may be accepted. The loser always pays the umpire charges.

REPRESENTATIVE SETTLEMENT COMPUTATIONS

Following is a series of hypothetical settlements which illustrate the features described in the foregoing pages. These settlements are computed on the open rates offered by smelters to anyone who desires to ship ore to them. Some of the ores considered would probably command different schedules if sold in large quantities on special contracts. For instance, the ore of Settlements A and B undoubtedly would command a premium at some smelters because of the high silica content. Settlements A and B are on the same ore computed on the open schedules of two smelters to illustrate the profit that occasionally may be derived by comparing schedules of different smelters and the freight rates to them. This ore would yield a small profit if sent to smelter X but would barely pay for treatment if sent to smelter Y.

It must be emphasized that the smelter settlements given simply illustrate the method of computing smelter returns on different classes of ores and concentrates. In view of the variable prices of all metals except gold, they can not safely be used for any other purpose. Metal prices used in the computations are those that were in effect late in 1930 and are as follows:

Gold, $20.67 per ounce; silver, 33 cents per ounce; copper, 10.5 cents per pound; lead, 5.1 cents per pound. In November, 1932, silver sold at 26.7 cents per ounce, copper at 5.1 cents per pound and lead at 3.0 cents per pound. On the basis of these lower prices both the gross and net values of all the ores considered would be materially reduced, and some of them would not pay the smelter costs. For example, at the prices given for November, 1932, the ore of Settlement D would be reduced in gross value per ton from $112.96 to $60.64, and the net proceeds would be reduced from $84.34 to $19.07; the ore of Settlement E, a gold-silver ore, would be reduced in gross value from $41.87 to $37.62, and the net proceeds would be reduced from $27.92 to $23.26.

Settlement A—Siliceous Copper Ore

Assay.

Silver, 0.2 oz. per ton.
Copper, 4.8 per cent.
Silica, 80.0 per cent.
Zinc, 1.7 per cent.

Gross value per ton.

Copper—(4.8%) 96 lbs. @ 10.5c	$10.08		
Silver—0.2 oz. @ 33c	0.07		
Total gross value	$10.15		
Credit per ton on smelter settlement.			
Copper—95% of (96–8) lbs. @ (10.5–2.5)c		$6.69	
Silver—below minimum		---	
Total credit			$6.69
Debit per ton on smelter settlement.			
Base treatment		$2.50	
Zinc—below free allowance		---	
Total debit			$2.50
Proceeds per ton.			
Proceeds from smelting			$4.19
Freight to smelter			2.10
Net proceeds			$2.09

Settlement B—Siliceous Copper Ore

Assay.

Silver, 0.2 oz. per ton.
Copper, 4.8 per cent.
Silica, 80.0 per cent.
Zinc, 1.7 per cent.

Gross value per ton.

Copper—(4.8%) 96 lbs. @ 10.5c	$10.08
Silver—0.2 oz. @ 33c	0.07
Total gross value	$10.15

Credit per ton on smelter settlement.

Copper—(96–10) lbs. @ (10.5–2.5)c	$6.88	
Silver—below minimum	---	
Total credit		**$6.88**

Debit per ton on smelter settlement.

Base treatment	$3.50	
Zinc—below free allowance	---	
Total debit		**$3.50**

Proceeds per ton.

Proceeds from smelting	**$3.38**
Freight to smelter	**3.30**
Net proceeds	**$0.08**

Settlement C—Copper Ore

Assay.

Gold, 0.30 oz. per ton.
Silver, 7.70 oz. per ton.
Copper, 8.8 per cent.
Lead, 0.6 per cent.
Silica, 36.0 per cent.
Iron, 11.5 per cent.
Manganese, 0.5 per cent.
Zinc, 0.8 per cent.
Bismuth, 0.1 per cent.

Gross value per ton.

Gold—0.3 oz. @ $20.67	$ 6.20
Silver—7.7 oz. @ 33c	2.54
Copper—(8.8%) 176 lbs. @ 10.5c	18.48
Total gross value	$27.22

Credit per ton on smelter settlement.

Gold—95% of 0.3 oz. @ $20.00	$ 5.70	
Silver—95% of 7.7 oz. @ (33–1.5)c	2.30	
Copper—95% of (176–8) lbs. @ (10.5–2.5)c	12.77	
Total credit		$20.77

Debit per ton on smelter settlement.

Base treatment	$ 2.50	
Silica deficiency under 60% excess over iron plus manganese. 36.0% silica - 12.0% iron plus manganese = 24.0%. (60.0–24)% @ 5c; maximum charge	1.50	
Zinc—below free allowance	---	
Bismuth below free allowance	---	
Total debit		$ 4.00

Proceeds per ton.

Proceeds from smelting	$16.77
Freight to smelter	2.90
Net proceeds	$13.87

Settlement D—Hand-Picked Copper Ore

Assay.

Silver, 8.6 oz. per ton.
Copper, 57.2 per cent.
Iron, 1.6 per cent.
Insol., 10.2 per cent.

Gross value per ton.			
Silver—8.6 oz. @ 33c	$ 2.84		
Copper—(57.2%) 1144 lbs. @ 10.5c	120.12		
Total gross value	$122.96		
Credit per ton on smelter settlement.			
Silver—95% of 8.6 oz. @ 33c		$ 2.70	
Copper—90% of 1144 lbs. @ (10.5–2.5)c		91.52	
Total credit			$94.22
Debit per ton on smelter settlement.			
Base treatment		$ 5.50	
Insoluble			
10.2% insol.–1.6% iron=8.6%			
8.6% @ 12c		1.03	
Total debit			$ 6.53
Proceeds per ton.			
Proceeds from smelting			$87.69
Freight to smelter			3.35
Net proceeds			$84.34

Settlement E—Gold-Silver Ore

Assay.

Gold, 1.2 oz. per ton.
Silver, 32.6 oz. per ton.
Copper, 3.0 per cent.
Silica, 68.0 per cent.
Iron, 5.3 per cent.

Gross value per ton.			
Gold—1.2 oz. @ $20.67	$24.80		
Silver—32.6 oz. @ 33c	10.77		
Copper—(3.0%) 60 lbs. @ 10.5c	6.30		
Total gross value	$41.87		
Credit per ton on smelter settlement.			
Gold—1.2 oz. @ $19.50		$23.40	
Silver—95% of 32.6 oz. @ 33c		10.22	
Copper—(60-10) lbs. @ (10.5-2.5)c		4.00	
Total credit			$37.62
Debit per ton on smelter settlement.			
Base treatment, maximum charge		$ 5.50	
Total debit			5.50
Proceeds per ton.			
Proceeds from smelting			$32.12
Freight to smelter			4.20
Net proceeds			$27.92

Settlement F—Silver-Lead Ore

Assay.

Gold, 0.62 oz. per ton.
Silver, 150.4 oz. per ton.
Lead, 17.6 per cent (wet).
Copper, 5.4 per cent.
Silica, 5.4 per cent.
Iron, 19.7 per cent.
Sulphur, 28.6 per cent.
Zinc, 6.0 per cent.
Antimony, 1.90 per cent.
Arsenic, 1.40 per cent.
Bismuth, 0.15 per cent.

Gross value per ton.

Gold—0.62 oz. @ $20.67	$12.81		
Silver—150.4 oz. @ 33c	49.63		
Lead—(17.6%) 352 lbs. @ 5.1c	17.95		
Copper—(5.4%) 108 lbs. @ 10.5c	11.34		
Total gross value	$91.73		

Credit per ton on smelter settlement.

Gold—95% of 0.62 oz. @ $20.00		$11.78	
Silver—95% of 150.4 oz. @ (33–1.5)c		44.70	
Copper—95% of (108–10) lbs. @ (10.5–3.75)c		6.28	
Lead—90% of (352–30) lbs.=289.8 lbs. Deduction for copper paid for=93.3x0.4= 37.2 lbs. (289.8–37.2) lbs. @ (5.1–1.5)c		9.09	
Iron—19.7% @ 6c		1.18	
Total credit			$73.03

Debit per ton on smelter settlement.

Base treatment on 25% lead content		$ 3.50	
Treatment penalty on lead below 25% (25.0–17.6)% @ 5c		0.37	
Insoluble—5.4% @ 10c		0.54	
Sulphur—(28.6–1.0)% @ 20c; maximum		1.00	
Zinc—(6.0–5.0)% @ 25c		0.25	
Arsenic—below free allowance		----	
Antimony—(1.90–0.5)% @ $1.50		2.10	
Bismuth—free allowance=17.6%x0.1%=0.02%, (0.15–0.02)%=2.6 lbs. @ 50c		1.30	
Total debit			$ 9.06

Proceeds per ton.

Proceeds from smelting			$63.97
Freight to smelter			3.35
Net proceeds			$60.62

Settlement G—Lead Ore

Assay.

Gold, trace.
Silver, 0.6 oz. per ton.
Lead, 11.1 per cent.
Available lime, 22.6 per cent.

Gross value per ton.

Silver—0.6 oz. @ 33c	$ 0.20
Lead—(11.1%) 222 lbs. @ 5.1c	11.32
Total gross value	$11.52

Credit per ton on smelter settlement.		
Silver—below minimum	$	
Lead—90% of (222–30) lbs. @ (5.1–1.5)c	6.22	
Available lime—22.6% @ 8c	1.81	
Total credit		$8.03
Debit per ton on smelter settlement.		
Base treatment on 25% lead content	$3.50	
Treatment penalty on lead below 25% (25.0–11.1)% @ 5c	0.70	
Total debit		$4.20
Proceeds per ton.		
Proceeds from smelting		$3.83
Freight to smelter		2.10
Net proceeds		$1.73

ZINC ORES

Zinc ores or concentrates are commonly paid for on the basis of a "standard" or "base" content. Under such contracts, the price for any lot is increased or decreased by a specified amount per unit variation above or below the "standard." Iron and sometimes lead are undesirable constituents. Most of the lead, copper, gold and silver remains in a residue called the "zinc residue" which must be smelted by the usual methods. Plants producing paint pigments may settle on a "standard" zinc-plus-lead content.

Some zinc schedules are similar to those used for copper and lead ores. These usually provide for payment of from 75 to 85 per cent of the zinc and from 65 to 80 per cent of the silver and lead. Treatment charges range from $16.50 to $22.50 per ton of ore.

SMELTING PLANTS

Following is a list of smelting plants to which New Mexico ores are usually sent.

Company	*Ores Purchased*	*Location of Plant*
American Smelting and Refining Co.	Zinc ores.	Amarillo, Tex.
American Smelting and Refining Co.	Copper, lead and dry ores.	El Paso, Tex.
American Zinc and Chemical Co.	Zinc ores.	Langeloth, Pa.
Blackwell Zinc Co.	Zinc ores.	Blackwell, Okla.
Empire Zinc Co.	Zinc ores.	Canyon City, Colo.
Mineral Point Zinc Co.	Zinc ores.	Depue, Ill.
Ozark Smelting and Mining Co.	Zinc, lead and copper ores.	Coffeyville, Kans.
Phelps Dodge Corp.	Copper, lead and dry ores.	Douglas, Ariz.
United States Zinc Co.	Zinc ores.	Henryetta, Okla.

CUSTOM CONCENTRATING MILLS[1]

Many New Mexico mines have considerable quantities of ores that cannot be shipped with profit directly to a smelter. This may be due to (a) the low metal content, (b) the distance to the nearest smelter which makes the freight on the ore prohibitive, or (c) the complex nature of the ore which prevents the smelter from paying for all of the contained metals, as described in the preceding pages. Some of these ores would yield a profit if they could be concentrated near the deposit and the concentrates delivered to the smelter, but many mines are unable to build and operate concentrating mills due to lack of funds or sufficiently large ore reserves. The custom mill supplies an outlet for the ores of these mines.

In 1930 two custom mills were operating in New Mexico: the mill of the Peru Mining Co. at Wemple, near Deming, Luna County, and the mill of the Black Hawk Consolidated Mining Co. at Hanover, Grant County.

The price paid for a ton of ore by the custom mill is necessarily very much less than the gross value of the metals contained as usually reported by the assayer of the ore. The custom mill must make due allowances for losses inevitable in both milling and smelting. A recovery of 85 per cent of the zinc content represents good milling on complex ores. The smelter will pay for only about 80 per cent of the zinc in the concentrate; hence the mill can pay only for 85 x 80=68 per cent of the zinc in the crude ore. From 80 to 85 per cent of the lead in the crude ore is finally recovered. A deduction of 1½ per cent from the wet assay of the lead content is usual, and if copper is paid for in a lead-copper concentrate the smelter may make further deduction from the lead paid for. The custom mill can allow only for a milling recovery of about 85 per cent of the copper in the crude ore and a smelter allowance of 85 to 90 per cent of the copper in the concentrate. Therefore it can pay for only about 75 per cent of the copper in the crude ore. Similarly from 81 to 85 per cent of the silver is all that the custom mill can pay for. All the gold may be paid for but at a price several dollars less than its established value.

A deduction from the market price of the metals is made by the custom mill to cover freight on concentrates from mill to smelter, freight on metals shipped by the smelter, and treatment charges made by the smelter on the concentrates. Freight and moisture deductions on the crude ore received at the custom mill are costs which obviously the raw material should stand. The treatment charge of the custom mill covers labor, crushing and sampling, transportation through the mill, power, reagents, filtering, replacements, depreciation, return on the investment, etc. Equipment wears out quickly or soon becomes obsolete, and

[1] Much of the data contained in this section was supplied by Mr. P. H. Argall, Manager, Peru Mining Co., Deming, N. Mex.

the cost of replacing it is especially large. Taking these factors into consideration the usual custom mill treatment charges are moderate.

MANGANESE

Manganese ores are commonly sold on the basis of so much per unit of manganese per long ton. Battery-grade ore, however, is sold on the MnO_2 content, which is the measure of the available oxygen content for which the ore is needed.

Manganese ores are commonly classified in the United States as follows:

(A) Manganese ore, which contains 35 per cent or more of manganese.

(B) Ferruginous manganese ore, which contains 10 to 35 per cent of manganese.

(C) Manganiferous iron ore, which contains 5 to 10 per cent of manganese.

During the past few years ferruginous manganese ore has been paid for at 10 to 20 cents per unit less than the price paid for manganese ore. More than 25 per cent of silica renders the ore non-commercial. Manganiferous iron ore is generally sold upon the combined iron and manganese content which is paid for at a price slightly higher than the current price for iron in iron ore. Iron ore which contains less than 5 per cent of manganese is sold on the same basis as manganiferous iron ore.

The following paragraphs are from a bulletin by J. W. Furness entitled "The Marketing of Manganese Ore."[1]

During the past few years the general practice [in the metallurgical industries] has been to divide first-grade ores into two classes—first, ores containing 50 per cent metallic manganese or more; second, ores containing from 47 to 50 per cent manganese. In the first class, where the ore contains in excess of 50 per cent, there is no premium paid for additional units of manganese, but a preference is obtained in the market. Metallurgical ores containing less than 45 per cent metallic manganese are salable, but, as a rule, unless specifically specified are subject to rejection by the consignee. Ores readily salable are those containing 50 per cent or more of manganese, not more than 6 per cent of iron, not more than 8 per cent of silica, and a phosphorus content not exceeding 0.2 per cent. Ores in which the ratio of iron to the manganese content is high are not capable of being manufactured into ferromanganese. As a rule, ores containing in excess of 8 per cent silica are penalized; in the United States the amount deducted from the price stipulated per unit of manganese is a matter of negotiation * * *. Lime ($CaCO_3$) is not objectionable, while alumina in excess of 10 per cent is considered highly objectionable. Copper, lead, zinc and barium are considered deleterious impurities when present in any appreciable quantity.

Settlements for the purchase of ore are based upon the analysis of samples dried at 100°C. Physical properties also play a part in the desirability of an ore from a metallurgical standpoint. An ore composed largely of fines not only clogs the flues in furnace, but the percentage of loss of the ore is increased by the fine particles being carried into the stack * * *.

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[1] Furness, J. W., U. S. Bureau of Foreign and Domestic Commerce, Trade Inf. Bull. 599, pp. 4-5, 21-25, 1929.

Manganese ore is purchased by the chemical trade on the basis of dioxide content. The manganese dioxide content varies in the commercial ores from 60 to more than 90 per cent. By far the larger part of manganese utilized in the chemical industry is required by the battery trade. In this use it is not the metallic manganese that is desirable, but the amount of available oxygen contained in the mineral. Pyrolusite, on account of its high dioxide content, is the mineral which usually supplies this industry. Theoretically, the amount of available oxygen in this mineral is 18.39 per cent. The physical quality of porosity largely governs the merchantability of the ore. The mineral should be sufficiently porous to allow free percolation of the acid through it, but of such a density as to prevent crumbling. In any case it is quite impossible to lay down specifications for chemical ores utilized in the battery industry, since it is necessary to find out by trials whether an ore having a correct chemical composition is suitable from the physical point of view. * * * Objectionable impurities are iron, copper, nickel, cobalt, * * * arsenic, and other metals electronegative to zinc. * * *

Specifications usually call for an ore containing at least 80 per cent MnO_2 (minimum available oxygen 14 per cent), less than 1 per cent of iron and less than 0.5 per cent of copper, nickel, or cobalt. Ores with a much lower content of available oxygen may be usable if they are porous enough. * * *

For use in the manufacture of chlorine, a chemical ore should be free from impurities that are soluble in the acid used for decomposing it. The presence of lime in the form of carbonate is objectionable. Ores that contain an excess of 2 per cent of this element are usually discarded. Ferrous compounds are objectionable. Phosphorus is harmless in ores used for the production of chlorine. * * *

As a rule, there is no fixed form of contract for the guidance of the buyer of manganese ore. As each individual lot is purchased the terms governing the sale are a matter of negotiation between buyers and seller.

Various forms of contracts are used in the United States. These contracts uniformly contain the following clauses: * * * The metallic manganese, silica, and phosphorus content are designated. At times the buyer requires limitations as to the iron content as well as to the alumina content. A clause is invariably inserted as to the permissible silica, and at times a premium is paid for less than the percentage named and a penalty deducted for the excess of this percentage. Almost invariably a contract mentions the permissible percentage of phosphorus. * * * In the United States, the price varies and a range between 0.15 and 0.25 per cent is tolerated. Where phosphorus content is specified, should the content run above the amount named the ore contract is subject to cancellation, although at times a clause is inserted covering penalty for an excess which is determined by the contract.

Under "Price" is given the price per unit in tons of 2,240 pounds net, dry weight. * * * These contracts also provide for the weighing, sampling, and determination of moisture at point of discharge, the name of the chemist to make the analysis of the ore, and method of umpiring should settlement so require. Should there be sufficient difference between the assays of the buyer and seller, and should this difference not exceed 1 per cent, settlement is made upon a split between the two assays. Should, however, the difference exceed 1 per cent, an assayer is selected by the buyer and seller, and on the result of his analysis settlement is made.

The contract under which ore from the Little Florida Mountains has been recently sold is probably typical of any contract that may be given on New Mexico ore. This contract requires a minimum of 40 per cent manganese and a maximum of 8 per cent silica. Excess silica is penalized at the rate of 30 cents per unit per ton. No allowance is made for iron or lime. A form of settlement for this ore is as follows:

Settlement—Manganese Ore.

Analysis.

Manganese, 50.0 per cent.
Silica, 7.03 per cent.

Value per ton.

Manganese—50.0% @ 50c	$25.00	
Silica—(Premium as per contract) (8.00–7.03)% @ 30c	.29	
Total value		$25.29
Freight		9.95
Net value per ton		$15.34

As a rule manganese ores in the United States are sold directly to the consumer. Most of the manganese ore mined in New Mexico has been purchased by steel manufacturers and independent ferromanganese producers. The Boston Hill manganiferous iron ore is sold to the Colorado Fuel & Iron Co. at Pueblo, Colo. The ores from the Little Florida Mountains district, which have furnished most of the manganese produced in New Mexico in recent years, have been shipped under contract to Birmingham, Ala., and to Reusens, Va.

Manganese ores produced in western United States are shipped to Birmingham, Ala.; Cleveland, Ohio; Pittsburgh, Marietta and Sheridan, Pa.; Chicago, Ill.; Pueblo, Colo.; and Reusens, Va. Under existing freight rates the best markets for New Mexico ore are Birmingham and Pueblo. Other markets, particularly Cleveland and Pittsburgh, could be reached advantageously under different rates. The present situation would seem to have its compensating features in that the existing relatively favorable freight rates to Birmingham and Pueblo give New Mexico an advantage over some other producing States.

The tendency in steel manufacturing in recent years has been to use ferromanganese in place of crude ore. Inasmuch as specifications generally require in excess of 47 per cent manganese in ore used in the manufacture of ferromanganese, and since most New Mexico ores are below this grade, the increasing use of ferromanganese in the steel industry has greatly limited the market for lower grade crude ore from the State. It is reported that up until about 1929 the Pacific Coast steel companies annually used about 3,000 tons of crude high-grade manganese ore but that these companies now use ferromanganese almost exclusively. The Pacific Coast was formerly a good market for high-grade New Mexico manganese ore.

Considerable work has been and is being done by the United States Bureau of Mines and by independent investigators on the beneficiation of manganese oxide ores by leaching, flotation and other processes. The high manganese content of the products of such processes makes these products desirable to the producer of ferromanganese. If some cheap leaching process is developed which will be commercially feasible, production of manganese in

New Mexico should benefit materially. In addition to being a more desirable material, the product is also a more concentrated one and as a result will require less freight per unit of manganese.

The price for manganese in 1928 and 1929 averaged about 60 cents per long-ton unit of 50 per cent ore. The 1930 price averaged less than 50 cents. The tariff on manganese enables domestic manganese ore to be sold at the point of consumption at about the same price as must be paid for foreign ores at the port of entry. Domestic ore thus has an advantage equal to the freight rate from the point of entry to the point of consumption so that, given proper freight rates and a reasonable cost of mining and concentrating, the domestic producer stands a chance of being able to dispose of all his ore at some profit.

The New Mexico deposits are commonly of the vein type and consequently are fairly expensive to mine. Actual total cost of mining, milling and transportation to eastern points for the Manganese Valley Mines ores in 1928[1] was $18.18 per ton, segregated as follows: Mining, $5.62; milling $1.87; transportation, $10.69.

IRON

Marketing of iron ores from New Mexico may be considered to have certain characteristics peculiar to itself. This is due to the fact that there is only one market available, the Colorado Fuel & Iron Co. at Pueblo, Colo. The Columbia Iron & Steel Co. has a plant at Provo, Utah, but its requirements are adequately supplied by local sources. As a result of this restricted market, all iron ore from New Mexico is shipped to Pueblo, Colo., under special contracts. The terms of these contracts are not available.

Iron ores are commonly sold on the tonnage basis with penalties and premiums per unit variation of iron and phosphorus from a fixed standard. Sulphur is always objectionable and the silica content must be within certain limits.

MOLYBDENUM

The second largest molybdenum mine in the United States is in the Red River district, New Mexico. This mine is owned by the Molybdenum Corporation of America which has its own plants for converting the ore into various alloys suitable for use in making molybdenum steel. Although consumption of molybdenum is gradually growing, the known deposits of molybdenum ore in this country have reserves far in excess of any probable demand for many years to come.[2]

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[1] U. S. Bur. Mines Mineral Resources, 1928, pt. 1, p. 218, 1931.
[2] The mineral industry, McGraw-Hill Book Co., Inc., vol. 38, p. 447, 1929.

Sales of ores or concentrates may be made upon the content of molybdenum, molybdenum sulphide or molybdenum oxide. In the United States sales are made at so much per pound of molybdenum sulphide if the ore is molybdenite, and molybdic oxide if the ore is wulfenite. Occasionally the equivalent content of metallic molybdenum is specified in place of the sulphide or oxide. The price in 1930 was about 40 cents per pound of molybdenum sulphide (MoS_2) delivered at Pittsburgh plants.

Allowance is usually made only for the principal molybdenum mineral present. Secondary or accessory molybdenum minerals in subordinate amounts are ignored, chiefly because they are lost in concentration. It is commercially impracticable to use material containing less than 65 per cent of molybdenum sulphide, and hence all ores must be concentrated before they can be marketed.

Antimony, arsenic, bismuth, copper, nickel, phosphorus and tin are considered undesirable elements in molybdenum ores. Barium and calcium in considerable quantities, except as silicates, are also undesirable. The maximum allowable quantity of impurities depends upon the purpose for which the concentrate is desired.

TUNGSTEN

Tungsten ores are generally marketed on the basis of 60 or 65 per cent tungstic oxide (WO_3). Tungsten ores differ considerably, however, and consequently users of tungsten concentrates prefer to buy a known product of a given mine or ores, upon which the analysis is guaranteed, not only of WO_3 but of the impurities also. Most tungsten ores must be concentrated in order to make a salable product.

Permissible impurities depend upon the reduction process by which the ore or concentrate is to be treated. Different buyers use different processes, of which there are three, namely: chemical, the electric furnace, and the thermit process. In the chemical process most of the impurities are eliminated and almost any ore can be used. When the electric furnace is used, producing ferrotungsten as a final product, the material must be as free from impurities as possible. An ore or concentrate to be treated by this process should contain more than 65 per cent of WO_3 and not more than 0.05 per cent each of tin, copper, phosphorus, arsenic and sulphur. The thermit process, in which the concentrate is fused with metallic aluminum, requires a concentrate of very high quality, free from impurities.

A list of consumers of tungsten ore in the United States is given by Spurr and Wormser.[1] Price is fixed by individual negotiations between buyer and seller. The open-market price in 1930 was about $10 per unit of WO_3 on the basis of 60 per cent WO_3 content.

[1] Marketing of metals and minerals, McGraw-Hill Book Co. Inc., pp. 195-196.

OTHER METALS

All the tellurium, nearly all the antimony and most of the arsenic produced in the United States are obtained as by-products from smelter operations. Bismuth is produced chiefly as a by-product in the refining of lead. Bismuth ores are seldom mined as such, the by-product output being sufficient to supply the demand.

Practically all the world's uranium-radium production at the present time comes from the Belgian Congo in Africa. The small quantities mined in the United States, some of which come from the White Signal district, Grant County, New Mexico, are sold for therapeutic purposes. There is no specific market for this class of material.

Concerning vanadium, Hess[1] states:

> The most widespread vanadium minerals, and therefore those with which the greatest number of prospectors come in contact, are the vanadium minerals occurring in the oxidized parts of lead veins. * * * There may be almost any combination of these minerals in a given deposit close at hand. The deposits are usually small, so that no large tonnage can be produced from any one mine, and the metallurgy, difficult at best, is thus complicated because processes must be rearranged for each new combination.

Hess[2] lists several firms which in 1925 were interested in lead vanadate ores.

Tin smelting is not practiced in the United States. Concentrates of this material must be sent abroad for reduction.

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[1] Marketing of metals and minerals, McGraw-Hill Book Co. Inc., p. 207.
[2] Idem.

PART V. ECONOMIC FEATURES OF PROSPECTING, MINING AND MILLING

DEVELOPMENT AND SALE OF PROSPECTS

This section of the report discusses briefly some of the major problems relating to the development of metalliferous prospects. Inquiries received by the State Bureau of Mines and Mineral Resources indicate that many prospectors and miners are poorly informed on these subjects.

The mining laws of New Mexico are given in Bulletin No. 6 of the State Bureau of Mines and Mineral Resources by C. H. Fowler which is entitled "Mining and Mineral Laws of New Mexico." The Federal and State mining laws do not coincide, and for mining claims on government lands the requirements of both must be complied with. For example, the laws of New Mexico do not specifically require discovery as a prerequisite to location of lode deposits, but the Federal laws do. Following the discovery of a vein or other ore deposit certain steps must be taken. A claim must be laid off, marked by suitable posts or monuments, a location notice posted, discovery work performed, and the location recorded within 90 days after posting such notice. The statutes concerning location of placer claims and those concerning the location of claims on Indian lands, State lands and Spanish and Mexican land grants embody special clauses not found in the general mining law, and those interested in locating and working mineral deposits in New Mexico should be conversant with these statutes. They are stated and discussed in Fowler's report. When the claim has been located properly as prescribed by law the owner is safe from interference and trespass, and the initial development of the deposit may be undertaken. In order to retain title $100 must be expended upon the claim each year, and after $500 has been spent in development and improvement the claim may be purchased from the government for a nominal sum and permanent title (patent) acquired. The details of acquiring patent should be ascertained by inquiry at the district United States land offices at Santa Fe or Las Cruces.

The surface usually offers the cross-section of a deposit that may be most cheaply and easily examined. Deeper development merely exposes other sections and should not be attempted until the surface has been thoroughly explored. The surface itself was at one time a deeper level, and if no ore is found by surface exploration, or no indication that ore once existed at this level, deeper work usually is not warranted. The surface is a fair criterion of conditions at depth if it can be interpreted properly.

The cost of surface prospecting is discussed under "Mining", pages 162-166.

Inasmuch as existence and distribution of ore bodies depend upon geologic relations, and since the prospector, for whom this is primarily written, usually does not have the proper geologic training to determine and evaluate those relations correctly, it would seem advisable for him in developing his find always to "follow the ore." This policy may be deviated from more or less safely in a well-developed district in which the general habits of the deposits are known. Exploratory crosscuts in barren ground are expensive, and furthermore mean less to a prospective purchaser than an equal amount of work done upon the vein itself. Also, the ore extracted in the course of "following the ore" may help defray the cost of development work. This ore, if sufficiently high-grade, may be shipped directly to the smelter; it may be hand sorted and the sorted material shipped; or it may be sold to a custom smelter or ore-broker. An incompletely explored property that can be made to pay its way, even if barely so, should never be abandoned until it becomes clearly evident that higher grade or more extensive ore will not be found. The current practice and trend in metallurgical processes should be borne in mind when working such a prospect.

Extracting all ore as quickly as it is exposed is a ready way to ruin a prospect and is justified only in leasing operations or in a property which has been practically worked out. There is always the temptation to loot a prospect during periods of abnormally high metal prices, but if the prospect contains unexplored reserves the additional money earned in this way is a doubtful gain, since the subsequent work in a mine so despoiled is costly above the average.

It is generally the prospector's intention to develop a property to the point where capital may be interested. Inasmuch as mines are wasting assets, promising prospects will always find a market. An examination and report by a reputable mining engineer or mining geologist is generally essential in order to interest capital. Above all, title to the property must be indisputable. Titles, maps, assays and reports carefully prepared and presented attract favorable consideration. Prospects are not expected to show ore reserves as a basis for consideration, but they are expected to show promise. A prospective purchaser usually insists on having an examination made by his own engineer, no matter who has examined the property previously. In preparing his prospect for this examination, the owner should place himself in the mental attitude of the examining engineer, who may not have the same enthusiastic and optimistic outlook as himself. The engineer is likely to be suspicious of every unusual feature, and a single hint of fraud, real or fancied, may be sufficient to stop negotiations.

One of the most important duties performed by the examining engineer is the sampling of the property. Frequently his results are lower than the owner expects them to be. The engineer's sampling is commonly done in a manner which will give accurate data as to the grade of the ore exposed. Lean parts are sampled as well as rich. The owner, on the other hand, commonly takes selected samples of the richer parts, or haphazardly chooses a few samples. Such samples almost invariably give a false estimate of value. A point to be borne in mind is that in some cases the stoping width may be greater than the vein width, in which case a sample of the vein will not be a true sample of the material that must be mined. A vein a quarter of an inch wide may contain $1,000 to the ton in gold, but if diluted with the adjacent country rock that must be mined with it, the resulting ore would be worth less than $8 a ton.

The presence of a moderate quantity of ore should not be considered too optimistically, as the prospective purchaser is interested in much more than the grade and amount of ore present. The engineer is certain to investigate the amount of development work that has been necessary to expose it. In many spotty deposits, such as are common in limestone, the cost of finding the ore is prohibitive. Regularity and size of ore shoots, structural characteristics, character of wall rock, and numerous other features have an important bearing on the cost of mining. Transportation facilities, availablity of water for camp and metallurgical uses, presence or absence of timber, underground water, and, for certain types of deposits, the amount of barren overburden are other important factors. Unless the net effect of these various features is favorable, an otherwise promising deposit may be given an adverse report.

The most common method of attracting capital and the one most likely to succeed, assuming that the prospect is otherwise favorably considered, is some form of the transaction known as the "bond and lease," in which a lease is acquired, carrying with it an option to purchase, in return for certain reimbursements and promises. These may include a system of rentals during the period of the option; deferred payments in the event that the property is purchased; agreement to do a certain amount of development work, generally within a specified period of time; royalties upon ore mined; and other contract features peculiar to the individual case. If the option to purchase is exercised, the purchase price may either include or exclude royalty payments already made under the lease. Capital expects an owner to have sufficient faith in his property to receive payments after and as ore is developed. The purchaser is usually unwilling to buy a prospect outright, but he is willing to devote the services of his staff and to risk his money in the hope that a mine may be developed.

MINING[1]

In this and the following sections the important economic features of mining and milling are considered. Present day costs of developing and operating mines have been carefully scrutinized by the writer, and the representative costs presented are based largely on the conditions of labor and wage rates prevailing in the State. Costs are so variable from one mine or district to another that average figures are not easily arrived at, nor would they have very much meaning; therefore, in most cases the maximum and minimum figures for any particular operation are given. A fair average figure for most estimates of a preliminary nature would be, perhaps, approximately the mean of the two when more specific information as to local costs could not be obtained.

Surface prospecting for ores comprises uncovering the vein by trenching, or by digging the usual pit or tunnel as required by law for assessment work. Trenching is inexpensive where the outcrops are buried under not more than 4 to 6 feet of surface detritus. Records on hand show that 6 to 9 cubic yards per man per day may be removed from trenches up to 6 feet deep in soil free from boulders. Depth and character of material may reduce these figures to 4 cubic yards per day. Where some grubbing has to be done and the material is dry and gravelly, costs may be around 75c to 80c per cubic yard. The presence of water and boulders will raise the upper cost limit to $1.40 or $1.50 per cubic yard.

Short shafts and surface tunnels similar to the work performed from year to year for assessment have cost from $2.50 per foot at and near surface to $7 per foot at depths of 30 to 50 feet in shafts and at distances of 300 to 500 feet in tunnels. Several small shafts 4 by 6 feet in section and 50 to 75 feet deep, drilled by hand and the rock hoisted by windlass, in medium ground, averaged $10 per foot for all items inclusive of superintendence. Hand-driven tunnels in this same character of ground and under similar conditions of work cost $4 to $6 per foot up to 300 feet, increasing thereafter with the distance.

Drilling to develop ore in the early stages of mining operations is frequently desirable in localities where the anticipated shape, size and attitude of the ore bodies make the work practicable, and a water supply may also be developed in this manner. Churn-drilling costs will vary from $1.25 to $2.90 per foot, for holes ranging in depth from 200 to 700 feet, when the work is handled on a large scale. A single portable churn drill operating in a district under unfavorable conditions may cost as much as $10 per foot of drilling to operate. These costs include the labor of securing accurate samples at 5-foot intervals, drying, and cutting them down to suitable size for handling at the assay office. Costs of diamond drilling under similar conditions are about the

[1] By G. T. Harley, geologist, New Mexico Bureau of Mines and Mineral Resources.

same as for churn drilling but diamond drilling has the decided advantage that the core, or continuous specimen of the rock being drilled through, gives more accurate geologic and other information than is supplied by churn-drill cuttings. On the other hand, the loss of a bit in the hole is a much more serious and expensive affair than the loss of a whole string of tools in cable work, and as a consequence much more experience is demanded of diamond drill operators. Some very light weight diamond drills are now on the market, capable of drilling 500 to 800 feet very economically. Diamond drills in shallow holes may advance between 20 and 40 feet per day of 24 hours. At greater depth this footage may drop off to 8 or 10 feet per day.

After preliminary prospecting has been concluded, the work of developing the mine for production is faced, and here one is on a little safer ground in making estimates, although large variations from the estimates may develop in most unforeseen quarters. Small 2-compartment shafts will vary in cost from $13 per foot to as much as $75, depending on the skill of the workmen, condition of the ground, water encountered, and cost of supplies and equipment. Shafts costing $15 to $25 per foot for this size of opening are probably normal. The cost of drifting underground will range from $5 to $10 per foot; raises of moderate length will cost from $4 to $8 per foot; and winzes not over 100 feet deep will cost between $7 and $15 per foot, exclusive of handling water.

Breaking ore in stopes may vary through a wide range of costs, depending on the character of the ground, shape and attitude of the ore body, method of mining adopted, wage scale in force, skill and interest of the miners, facilities for moving broken ore, support needed for broken or caving ground, cost of supplies required, and other factors. Sorting ore from waste in stopes introduces the largest single variable in the total cost. In average open stopes mined by the room-and-pillar system, where no sorting is done, the costs will vary between 90c and $1 per ton for ground of medium hardness. Where timber is required to support wide stopes or heavy ground as in the top-slice, square-set, or other methods of stoping, the cost of stoping may be $1.50 to over $3.50 per ton. On the other hand, when a block of ground can be undercut and drawn off by some modification of the caving method, costs may vary between 50c and 85c per ton. Great care should be exercised with this latter method, however, for lowering the grade of the ore drawn by diluting it with low-grade or waste rock, with the attendant disproportionate reduction in mill recoveries, will often make the cheaper mining cost figured on a per ton basis actually the more expensive method when considered from the standpoint of the ultimate profit return per pound or per ounce of recoverable metal. Labor accounts for 60 to 80 per cent of the total cost per ton in stoping, and 50 to 70 per cent of total mining costs.

In overhand stoping with hand drilling in veins, where the stope is carried 30 inches wide as the minimum economic stoping width and with pay streak as shown, the following table summarizes fairly well the costs to be expected:

Cost of Stoping in Dollars per Ton in a Stope 30 Inches Wide with Pay Streak as Shown

Width of pay streak in inches.	3	6	9	12	18	24	30
Steep vein.							
Hard.	10.60	9.25	8.27	7.75	5.25	5.00	2.50
Soft.	6.15	5.50	5.00	4.50	3.07	2.50	
Flat vein.[a]							
Hard.		14.25		11.25		5.75	3.00
Soft.		10.25	9.10	8.00	6.00	4.25	2.50

[a] Less than 45° inclination.

Transportation of ore underground with wheelbarrows or small mine cars is an important item of cost, and unless the mine is well planned it may soon become excessive. Wheelbarrows hold from 175 to 300 pounds of material under usual conditions, and a man working steadily will load, tram and dump ore over a maximum distance of 50 feet, at the rate of 5 or 6 tons per shift. With small cars of 12 to 16 cubic feet capacity operating over the light rails usually encountered in small mines, a loading, tramming and dumping duty of 10 cars per shift with a tramming distance of 300 feet is about an average figure. When loading from chutes the trammer should handle 20 cars or more per shift.

Removing water from mines may be quite expensive. Bailing from shallow shafts with the ordinary type of water bucket and a gasoline hoist will cost as high as 7c per 100 gallons per 500 feet of lift, but the cost will be as low as 1c per 100 gallons per 500 feet of lift from deep shafts equipped with large hoists and automatic bailers. Pumping with air lift or compressed air operated pumps is cheaper in general than the practice of bailing, but the initial expense is greater, and unless a steady flow of water has to be handled, such an installation is not always well advised. In shafts less than 250 feet deep, making small to moderate amounts of water, a pipeline with footvalve and sucker rods may be installed in the shaft, to be operated by an ordinary windmill type of pump jack driven by a gasoline engine on the surface.

Haulage of ore, concentrates and supplies between the mine and the railroad is a very important item at many places in New Mexico, and with auto trucks not less than 10c per ton-mile should be used in estimates for either contract or company-account handling. Sometimes light supply shipments are taken to the mines free by the freighting contractor or at half rates, but without definite agreement this should not be relied upon when making estimates.

In developing the small mine it is usually advisable to do as much development work as possible in ore, thus eliminating or greatly reducing the dead work in waste rock except that needed to provide hoisting and tramming passages, or to crosscut from one ore body to another, or for short prospect drifts in the walls of veins. It is not always good practice to strive for the lowest cost per ton of ore broken, as in many instances a higher cost per ton and fewer tons per man shift, a more closely sorted ore for shipment, and a higher grade waste dump which may be treated economically and at a substantial profit at some future time, are productive of larger ultimate profits than is a large tonnage of low-grade ore shipped immediately on which a minimum profit per ton is realized. During the period of development, all ore broken which must be brought to the surface should be marketed, if it will pay the expense of hand sorting, trucking, freight, and smelting charges, and yield even a small profit. The returns obtained in this manner may aid materially in reducing the financial outlay necessary to develop the mine. The marketing of ores and concentrates is discussed on pages 140-158. Development of the mine should be carried on with minimum equipment commensurate with the size of the ore body being developed and with special attention to low cost per unit of work done, and an enlarged plant should not be considered until ore is actually in sight and blocked out, the profits from which will pay back the new construction cost in the time limit set.

An important item of capital expense at a mine of any size and permanence, especially in an isolated locality, is that incurred for housing and feeding the employees. Poor accommodations and poor food in a mining camp are costly attempts at economizing which result in an excessive labor turnover, the cost of which rapidly outstrips any saving affected in the housing and feeding of the men. A change house with showers, a reading room, and a comfortable boarding house are essential parts of the equipment of the present day mine. Cottages for the married men and good bunk houses for the single men are an effective means of insurance against a high cost of labor turnover. In a climate which is mild throughout the year, commodious and well-screened tent houses may serve for the very small mine, but at the larger plants sealed cottages and bunk houses are required. An office building, supply house and sheds, blacksmith and machine shop, and some sort of timber framing shed and storage space are essential, and a covered space for trucks, tractors, and both company and employees cars is desirable. In or near an already established town much of this campsite construction can be dispensed with.

Change houses constructed of wood frame and corrugated iron should provide 8.5 to 10.5 square feet of floor per man, including showers and wash bowls, and will cost $18 to $20 per man, or from $1.75 to $2.35 per square foot of floor space. The cost of ordinary dwellings and plant buildings may be roughly estimated on the basis of the cubic feet of total volume. Some of these figures are as follows: One-story frame dwellings with cheapest type of finish, 5c to 9c per cubic foot; two-story frame dwellings similarly constructed, 7c to 9c per cubic foot. Small cellars under dwellings add about $200 to the total cost of the house. Small buildings such as offices, warehouses, etc., will average in cost between 7c and 10c per cubic foot; while well-constructed sheds, garages and barns will cost between 1.5c and 3c per cubic foot in about the order named. The cost of dwellings given above includes water piping carried into the house and inside toilets, and wherever possible a water system and sewerage should be installed.

The cost of reopening and equipping an old mine may range from $100 to $300 per ton of daily capacity. These figures include cleaning out old workings, retimbering caved and weakened sections of the mine, sampling of all exposed faces of ore and stope fill, providing the mine with tracks and drainage or pumping equipment, headframe, hoist, shaft equipment, blacksmith shop, compressor, timber yard and framing shed, office building, supply house, tools, drills and other working equipment. They do not include the cost of new development work to find other ore bodies, camp construction costs, or mill erection. Similar costs for a new mine may range from $250 to $500.

MILLING[1]

The problem of milling at a small property is often an important one, and the erection of a plant before it is warranted has been the cause of failure of many mines. Milling is advisable for some ores and essential for others. It serves three purposes: (1) It extracts waste matter from the ore and thereby eliminates transportation and smelting charges on valueless material; (2) it produces a concentrate which can be marketed where the original low-grade material possibly cannot; and (3) in the case of a complex ore a number of salable products are produced from the crude ore which otherwise could not be profitably marketed. The zinc minerals in complex ores can be separated from the other minerals and a zinc concentrate made in addition to other concentrates, whereas the zinc in the original ore would be penalized by the lead or copper smelter, or if the original ore were sent to a zinc smelter the lead and copper would not be paid for.

Many small companies with insufficient funds to develop the property to a point where ore blocked out fully warrants the construction of a mill, feel that if a small mill could be erected to treat development ore as it is broken, the development work

[1] By G. T. Harley.

would thereby pay for itself. This is good reasoning in principle, but several practical points serve to make it a hazardous practice: (1) Most prospects (95 per cent or more) do not in the end develop enough ore to make mines of them; (2) at many properties where good tonnages of reserves are finally blocked out, the average grade is materially lower than the early development work seemed to promise; and (3) without adequate figures on tonnage and grade of ore reserves, and on the distribution of the oxide and sulphide minerals in the ore, mills are usually built that are too large and costly and not well designed metallurgically. In general it should be obvious that during the development period the avoidance of all possible capital expenditures should be a prime consideration, and that it would be more practical in most cases to prepare a hand-sorted product for shipment, or to send the development ore to a nearby custom milling plant, if available, for beneficiation before shipment to the smelter, rather than to construct and operate a mill.

A valuable recent article by Baker[1] discusses the cost of erection and operation, the proper type, and the proper time to build a mill at a small gold mine. Baker's figures have been incorporated in the following tables compiled largely from the writer's experience, and this and the following paragraph have been abstracted from his article. The first question is whether any mill at all is justified. This will depend on (a) the grade and quantity of ore in sight and reasonably to be expected, (b) the character of the ore as it affects the recovery work of the mill, and (c) the financial resources of the owners. Ore worth only $3 to $4 per ton (gross value) can rarely be worked profitably except on a large scale. Ore worth $5 to $6 per ton can be made to pay under very favorable conditions on a scale of 100 tons per day, but as a rule $6 ore requires a 200- to 300-ton mill before the operation can show a profit. In many places $8 to $10 ore can be mined and treated at a profit on a 75- to 100-ton basis if it can be treated simply. In general $12 to $15 ore is the minimum to be considered for a 25- to 50-ton mill. Obviously the treatment of tailings dumps, old stope fills, etc., might constitute an exception to the foregoing.

Small flotation plants will cost between $600 and $800 per ton of daily capacity to purchase and erect (all new materials), amalgamation plants will cost $600 to $1,000 depending on whether tabling or flotation follows the plating process, cyaniding with fairly coarse crushing and tabling or flotation following will range around $1,000, while all-slime cyaniding mills will vary between $1,500 and $1,750 per ton of daily capacity.

The costs of mill erection and equipment in the following table are for wood or wood frame construction with concrete floors and foundations, and with new machinery and equipment

[1] Baker, John A., Mill equipment for the small gold property: Min. & Met. vol. 13, No. 305, p. 209, May, 1932.

used throughout. These costs are the averages of as many examples as it was possible to secure. Extreme variations in costs may be due to a number of factors, such as location, amount of preliminary testing work done on the ore, developing the necessary water supply, etc.

Cost of Mill Erection and Equipment in Dollars per Ton of Daily Capacity

Daily capacity, tons.	50	100	150	200	300	400	500
Coarse concentration (jigs and tables).	500	500		450			390
Fine concentration (tables and flotation).	800		690				826
Fine concentration (flotation only).	700				650		450
Stamps and amalgamation.	600	770	500		615		500
Stamps, amalgamation and tabling or flotation.	900	850		870		850	800
Stamps, amalgamation, tabling and cyaniding.	1000						
Fine crushing and cyaniding (all-slime).	1600	1050		810	667	1100	
Fine crushing, flotation and cyaniding.	1000	1000		800			750

The recovery of the metals will vary considerably between ores and between methods of mining and milling used, but it may be summarized in a general way as follows: For coarse concentration the recovery is about 60 to 65 per cent. Fine concentration by means of tabling and flotation yields from 70 to 85 per cent on ores of moderate grade, as does also the treatment by flotation only. Stamp milling followed by amalgamation yields 60 to 70 per cent of the free-milling gold and 15 to 25 per cent of the amalgamable silver, while with tabling following the plates 65 to 80 or even 90 per cent recovery of the contained metals may be made. Cyaniding, whether preceded by amalgamation and tabling, or by flotation, returns 85 to 90 per cent of the metal content, and by an all-sliming treatment as high as 98 per cent gold recovery is not unknown. The recovery of silver from its ores is usually less than the percentage recovery of gold by a similar process, and even in the all-sliming method, silver recovery will range between 80 and 90 per cent.

In the following table of milling costs the figures are averages only, and the individual figures entering into them showed an extreme variation in all of the small tonnage groups which tended to decrease in the larger tonnage groups. While these figures should serve for preliminary estimates, they should not be accepted for use in estimates of a more detailed nature until carefully checked against local conditions.

Cost of Milling in Dollars per Ton Milled

Daily capacity, tons.	50	100	150	200	300	400	500
Coarse concentration (jigs and tables).	1.00	1.01		.97	.90		.87
Fine concentration (tables and flotation).	2.00		1.75		1.80		1.33
Fine concentration (flotation only).	1.75		1.55		1.35		1.18
Stamps and amalgamation.	1.00		.87				.53
Stamps, amalgamation, and tabling or flotation.	1.50	1.42		1.00			
Stamps, amalgamation, tabling and cyaniding.	2.50				1.14		
Fine-crushing and cyaniding (all-slime).	3.00			4.60	1.99		1.51
Fine crushing, flotation and cyaniding.	2.50			2.00			1.57

The problems of the custom mill in the small mining districts are essentially the same as those for a mill at the individual mine. The best available technical advice should be obtained. Before erecting a local custom plant, agreements should be entered into with the various mine owners of the district, and of neighboring districts if possible, to insure a definite daily tonnage for a given period, and the mill erected should not be larger than this tonnage warrants. Tonnages in sight and reasonably to be expected at the various mines should be carefully checked for grade, tonnage, and amenability to the treatment process proposed, by an independent and competent engineer. Probably the cost of the plant, if economically built, should be returned to the owners in the form of profits in less than a year rather than in a longer period. After the plant has been paid for, if more ore has been found in the districts supplying it, the owners of the plant could then revise their treatment charges downward and permit the shippers in the region to mine lower grades of ore at a profit. The cost of custom milling and rates charged are discussed under "Custom Concentrating Mills," pages 152-153.

The water requirements for a mining camp and mill are often given inadequate consideration prior to the period of construction, and the following figures should be of considerable interest as an indication of the large quantities of water which must be assured before continuous and successful operation of the plant can be expected.

Water Requirements for Mining and Milling

	Maximum.	Average.	Minimum.
Domestic uses, gallons per person per day.	100	30	10
Cooling water and steam generation, gallons per horsepower per hour.	50		10
Concentrating plants, gallons of water in circulation per ton of ore treated:			
Jigs and tables.	7200		6500
Jigs and flotation.	3840	1920	960
Tables and flotation.	1500	1100	900
Flotation only.	1176	960	840
Stamps and amalgamation.	1000	925	800
Stamps, amalgamation, and tabling or flotation.	1500	1100	900
Stamps, amalgamation, tabling and cyaniding.	4800	3600	2400
Fine crushing and cyaniding (all-slime).	360	240	144
Fine crushing, flotation and cyaniding.	1200	1000	850

At some plants no water is saved after it has been used in milling operations, but in the Southwest very little milling is done on this basis, and water recovery may range between 40 per cent and 80 per cent with 50 per cent as a fair average. The losses are accounted for through evaporation, leakage, and discharge with the tailings and concentrates. To maintain such a water supply requires: (1) A dam across a flowing stream with large enough storage capacity to offset seasonal shortages; (2) deep wells having uniform annual flow, adequate pumping machinery, and smaller surface storage capacity; or (3) shallow wells subject to some seasonal fluctuations with a correspondingly larger surface storage capacity at the plant.

GENERAL ECONOMIC FEATURES[1]

In mining and milling operations, overhead expense may vary from a few cents per ton mined in the case of the individual operator to $1 per ton in the case of the small company, this latter figure being the safe one to use in preliminary estimates. The chief items included in this overhead expense are: superintendence, management, campsite and road maintenance, legal expense, consulting work, head office expense, supply purchasing when done by an outside agency, expert accounting, and other items of expense which cannot be charged definitely to one of the local operating departments.

With the figures given in the preceding sections for capital expenditures for mine and mill plant construction and equipment, and the operating requirements of the small to moderate-sized plant in mind, it is evident that in even the most favorable circumstances the development of a mine from the date of its discovery to the start of production is a matter of no small cost. A large financial outlay equivalent to $1,000 to $2,000 or even as high as $3,000 per ton of estimated daily capacity must be borne by the owners, before the plant is equipped for full-scale operation. The following table illustrates in a very general way the possible combinations of costs that go to make up the total pre-operating expenditures at the property, it being understood that these figures include no underground development or other strictly operating figures.

Cost of Mine Plant of Moderate Size in Dollars per Ton of Daily Capacity

	Low.	Medium.	High.
Mine.	300	400	500
Mill.	600	900	1200
Campsite.	100	300	500
Miscellaneous equipment.	100	200	300
Total cost.	1100	1800	2500

[1] By G. T. Harley.

The amounts of the above table will be spent over a period of one to three years or more, before production on any considerable scale will be possible, and during the period that this capital is thus tied up deferred interest charges are accruing against it. A mine which can produce ore and make an operating profit of 30 per cent to 50 per cent is the exception rather than the rule under normal conditions, but of this operating profit 10 per cent to 15 per cent only is available to the owners as profit, the remainder being properly placed into reserve or contingency funds to take care of the amortization of the property, depreciation in the value of the plant, development of new ore bodies or properties to take the place of those exhausted, and for the payment of local, state and Federal taxes.

A mine is a wasting asset in that after the ore reserves are mined out, the property and all improvements on it no longer have a value other than that attached to grazing lands and scrap metals. The successful mining venture is one that takes this state of affairs into full consideration and which in the end pays back to the owners: (1) All money invested in the capital stock of the company; (2) interest for the use of these funds at the current rate for the full time that they were in possession of the mining company, including the interest accruing during the construction period; and (3) a profit over and above the interest rate allowed which is entirely legitimate and is due the owners of the capital funds for the added risk they assumed in supplying funds for the development of the mine to a state of productiveness at which it could earn the estimated and hoped-for profits.

It is usually not necessary to pay back out of annual earnings the full amount of the capital funds borrowed. If it is considered that the date for the final payment of capital is the date when the mine is exhausted, the annual payments made from operating profits may be considered as payments made before due date, and they can be placed in a reserve fund bearing compound interest until the date for final payment arrives. If these annual funds are invested in safe securities at a normal rate of 3½ per cent to 5 per cent interest, the addition of this amount of interest, annually compounded by reinvesting, will materially assist in the payment of the capital at due date, so that the annual additions to the reserve fund from operating profits may be smaller by the deficiency which is made up by the interest earnings. This method of returning capital funds to the owners at the end of the operating life of the mine is known as "amortization." Quite often it is the practice of mining companies to include in the annual dividend payment the amount of the annual payment for amortization, and to carry on the books only a statement of this payment, calculated at the usual interest rate so that at the end of the life of the mine, the stockholder, if he had put that portion of his dividends away at interest each year as indicated, would have a sum on hand equal to his initial investment. In the majority of cases the stockholder prefers this method of receiving the payments, as he feels that he can invest the money to better advantage and with greater return to himself.

The depreciation reserve is a sum set aside each year, based on the number of tons mined and treated in the plant, for the purpose of buying new machinery or equipment to replace that worn out before the mine is exhausted. At the end of the life of the mine this reserve will total in amount the sum spent for the equipment of the plant and may be returned to the investor as repayment of that part of his capital loan to the company.

The cost of developing the ore reserves of a mining property is quite properly a part of the cost of mining that ore, and it should be charged off at a given rate against each ton of ore mined. Before the mine has started to produce, the expense of development must be paid out of capital funds, and this is a further drain on the owners in all but the few cases where mines have paid all such expenses from the grass-roots down. It is usual in such cases to set up a deferred development account on the books of the company, and after the mine has entered upon the production stage, this account is wiped out by charging it against each ton mined from the blocks of ground which were actually developed by the money involved.

In considering the advisability of acquiring or investing in a small mining property, the rule adopted by many mining companies and examining engineers is as follows: The total net value (smelter returns) of the recoverable metals in the ore reserves and in ore reasonably to be expected should be at least double the total probable operating and overhead cost, liberally estimated, of producing and milling this ore. If the items of purchase of property, organization of the company, and plant construction costs are added to the foregoing estimate to arrive at a total cost of producing the metals in the ore, then the net smelter returns should exceed this estimated probable total cost by at least 50 per cent. In addition and as a limitation on the above rule, there should be enough ore blocked out, and it should be of such grade, that the total cost of the plant can be paid back out of the operating profits preferably in one year and certainly in less than three years.

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