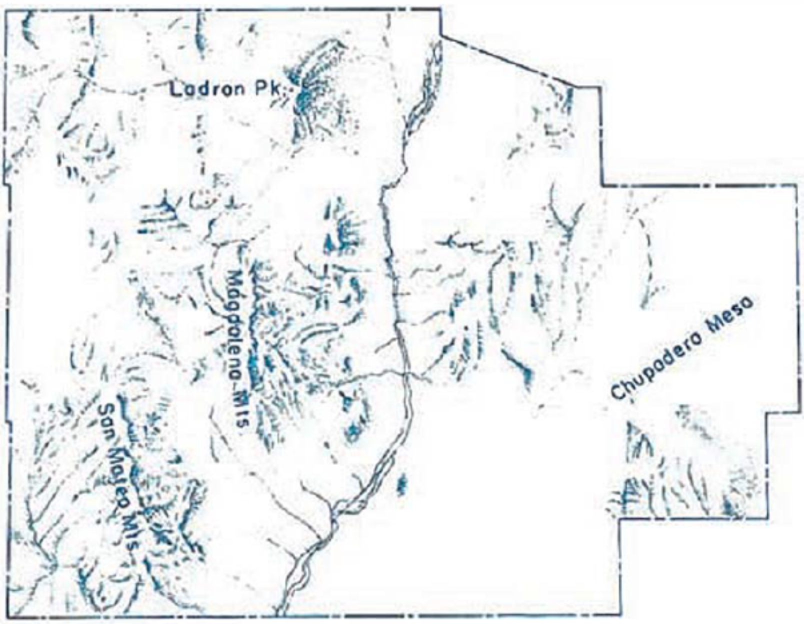
The Ore Deposits of Socorro County, New Mexico

by SAMUEL G. LASKY



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CONTENTS

CONTENTS

CONTENTS

CONTENTS

Page

ILLUSTRATIONS

The Ore Deposits of Socorro County, New Mexico

By

Samuel G. Lasky

INTRODUCTI ON

Socorro County, the largest political subdivision in New Mexico, presents a great diversity of physiographic and geologic features. This bulletin embodies the results of an investigation of the ore deposits of this interesting area.

In 1904, with the co-operation of the New Mexico Territorial Board of Managers of the Louisiana Purchase Exposition, a report entitled "New Mexico Mines and Minerals" was published by Fayette A. Jones. This volume included descriptions of several districts and camps in Socorro County. The county was visited by L. C. Graton and C. H. Gordon in 1905 in connection with a general reconnaissance of the state made by the United States Geological Survey, and their reports were published in 1910 as part of a general report, "The Ore Deposits of New Mexico"[1]. Most of the field work leading to the present report was done by the writer in the summer and fall of 1929, but the field work in the Socorro Peak district was not completed until the spring of 1931. Additional work was done in the San Jose district in April, 1932, following the discovery of the Pankey vein in the summer of 1931. The writing of the report was delayed by other assignments.

The writer has attempted to give a fairly complete description of each mining district based as much as possible on his own observations, and to discuss the future possibilities as fully as seemed warranted. In many places, however, the mines and prospects had been idle so long that workings were inaccessible, and many statements in these descriptions are based on information which could not be verified. Such information has been discriminated in the text from statements based on the writer's own observations, particularly where it has some bearing on the discussion of future possibilities. It is believed that the detailed descriptions which form the body of this report include practically all reported occurrences of metallic minerals in the county, with the exception of iron and manganese. These will probably be covered by a separate report at some future date. Two contact-metamorphic

[1]Lindgren, Waldemar, Graton, L. C., and Gordon, C. H.; U. S. Geol. Survey Prof. Paper 68, 1919.

iron deposits which are of particular interest are included. They are the Jones Camp deposit and a deposit north of Fairview. The descriptions of these two deposits are briefly abstracted from reports by others.

ACKNOWLEDGMENTS

The writer desires to thank the owners and other interested persons for their permission to visit the different properties and for their kindly assistance. He also desires to thank those who, though not directly interested in this report, have been of material assistance through the courtesies they have extended, particularly Messrs. H. O. Bursum and T. B. Ever-heart of Socorro, Paul B. Moore of Magdalena, W. H. Ritch of Tularosa, Philip Zimmer of San Acacia, and T. McDonald of Mockingbird Gap.

GEOGRAPHY

LOCATION

Socorro County covers an irregular area of approximately 7,550 square miles in the southwest-central part of the state. Plate I, a map showing the location of the principal mining districts, shows also the relation of Socorro County to the adjoining counties. At one time Socorro County included what is now Catron County and continued as far westward as the Arizona state line. The two counties were separated July 1, 1921. Socorro, the county seat, is situated on the west bank of the Rio Grande at about the center of the county.

TOPOGRAPHY

Socorro County lies in an area of desert basins out of which a number of mountain peaks and ranges rise abruptly. The highest point in the county is Big Baldy in the Magdalena Mountains, which has an elevation of over 10,830 feet; the lowest elevation is about 4,400 feet where the Rio Grande leaves the county.

The Rio Grande valley roughly bisects the county in a north and south direction and is the chief physiographic feature.[1] In the northern part of the county the valley is bounded on the west by the Ladrones, Lemitar and Socorro Mountains, named from north to south. South of the Socorro Mountains the west side of the valley spreads out to the rugged San Mateo Mountains which confine it as far as the southern boundary of the county. On the east side of the Rio Grande and at the north end of the county, the valley abuts against the Los Pinos Mountains, which are a continuation of the Sandia-Manzano uplift. Southward the valley merges more gradually into the ragged hills and plateaus which line the east side from the Joyita Hills, west of the Los Pinos Mountains, to Carthage. South of Carthage the Rio Grande depression is separated from the Jornada del Muerto by a divide which is only a few hundred feet higher than the river elevation.

Below the general level of the Rio Grande valley proper and bounded by the roughly dissected terraces along its banks is the flood plain of the river. The land of this flood plain is irrigated and supports profitable small farms and orchards. The principal towns and settlements and the main routes of travel are located in this area. The principal tributary streams are the Rio Puerco, north of the Ladrones Mountains; the Rio Salado which occupies the valley between the Ladrones Mountains on the north and the Bear and

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[1]Bryan, Kirk, Ground water reconnaissance in Socorro County, New Mexico: N. Mex. State Eng. Seventh Bien. Rept., p. 81, 1926 .

Lemitar Mountains on the south; Mulligan Gulch between the Magdalena and the San Mateo Mountains; and the Alamosa River which drains the western and southern parts of the San Mateo Mountains. All these streams drain the area west of the Rio Grande.

The Magdalena Mountains are in the west-central part of the county. West of them are the great Plains of San Agustin, which form a broad basin 12 to 20 miles wide north of the San Mateo Mountains and south of the Datil Mountains. The Plains of San Agustin extend southwestward into Catron County. Rounded hills of volcanic rocks rise out of the plains near and along their borders.

The narrow southward continuation of the county includes the San Andres Mountains, a long monoclinal range extending northward from Dona Ana County and presenting a gradual slope to the Jornada del Muerto on the west and a precipitous slope to the Tularosa Valley on the east. North of the San Andres Mountains the Jornada del Muerto abuts against the steep west slope of the Oscura Mountains. These merge northward into the Cupadera Mesa. The Jornada del Muerto or "Journey of the Dead"—so named by the Spaniards because of its inhospitable nature—is a wide southward-trending desert valley which occupies a large part of eastern Socorro County.

CLIMATE AND VEGETATION

The diversity in altitude and abrupt topographic changes

Climatological Data for Socorro County

Station	Elevation, feet	Mean annual precipitation, inches	Period of maximum precipitation	Days per year with 0.01 in. or more precipitation	Average annual snowfall, inches	Mean annual temperature	Mean annual maximum temperature	Mean annual minimum temperature
Socorro	4,600	11.05	July-Oct.	52	8.2	57.4°	74.1°	40.7°
Magdalena	6,556	14.50	July-Aug.	54	25.3	51.6°	66.0°	37.1°

in Socorro County lead to considerable variety in climate and vegetation. In the Rio Grande valley and on the plains the climate is warm and dry. The average temperature in the valley is about 57°, and extremes of heat and cold are unknown. The average annual rainfall in this area is about 11 inches with the period of greatest precipitation occurring from July to October. Light snowfalls are infrequent and ephemeral. Unpleasant south winds, heavily sand-laden, are common in the spring and occur at times in the fall.

In the mountainous regions the fall of rain and snow is greater and the temperature lower. Snow first appears in the higher parts generally in November, and these areas are usually covered with snow for several months each year.

The accompanying table summarizes climatological data[1] for the two United States Weather Bureau stations in Socorro County.

The data for Socorro may be considered representative of the valley region, whereas those for Magdalena may be considered representative of the mountainous areas.

The differences in meteorologic conditions have resulted in a considerable variety in the vegetation of Socorro County. In the Rio Grande bottoms cottonwoods are abundant, and there are varying growths of willows, tamarisk and other small trees and shrubs. The slopes bordering the valley bottoms are scantily clothed with vegetation, but there is a perceptible increase nearer the foothills. Range grass is sparse in places but fairly abundant on the higher plains and mesas and on the mountain slopes. On the mesas and bolson plains the larger forms of vegetation consist chiefly of cacti, greasewood, yucca (bear grass and soapweed), and mesquite. In the foothills and on the lower slopes of the mountains scattered scrubby growths of ash, cedar and juniper appear. The higher elevations in many places support excellent growths of yellow pine, cedar and juniper. Moderate amounts of timber have been cut in the Magdalena and San Mateo Mountains.

The Rio Grande valley bottom in Socorro County has been cultivated for many years by irrigation. During the present century more silt has been supplied by the tributary streams than the river has been able to transport, and the resulting aggradation has caused the water-logging of large areas that were formerly productive. The Middle Rio Grande Conservancy District was organized in 1927 for the purpose of providing adequate irrigation, drainage and flood control for the part of the valley which it includes. Construction work began in 1930. The chief crops in the past have been alfalfa, grain, fruit and vegetables. Recently cotton has been grown successfully near Socorro.

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[1]U. S. Dept. of Agriculture, Weather Bureau, Summary of climatological data for the U. S (to 1921 inclusive ; Sec. 5, northwest N. Mex.

GEOLOGY

THE ROCKS

GENERAL FEATURES

All the sedimentary rock systems from the Cambrian to the present, with the possible exception of the Jurassic, are represented in Socorro County. The principal features of the sedimentary rocks are given in the accompanying table.

The valleys and basins of Socorro County are largely floored with Quaternary detrital deposits. Tertiary sedimentary rocks occupy fairly large areas on both sides of the Rio Grande. East of the Rio Grande the older rocks are largely sedimentary and of Pennsylvanian, Permian, Triassic and Cretaceous ages. In the San Andreas Mountains older Paleozoic sedimentary rocks are exposed. Pre-Cambrian rocks outcrop in a number of places, and there are several small areas of Tertiary volcanic rocks.

West of the Rio Grande, Tertiary volcanic rocks are predominant. Pre-Tertiary sedimentary rocks are important in the northwest corner of the county, and in relatively small areas in the Ladrones, Lemitar, Socorro and Magdalena Mountains. The underlying Pre-Cambrian rocks are exposed in all these mountains.

PRE-CAMBRIAN ROCKS

The pre-Cambrian rocks consist of granite, gneiss and smaller amounts of ancient sediments now represented by schist, quartzite and argillite ("greenstone"). The granite and much of the gneiss are red. Amphibolite schist and granite gneiss are common in many places. Both sedimentary and igneous rocks have been intruded by dikes and other masses of dioritic rocks, and aplite and pegmatite dikes are prominent locally.

Pre-Cambrian rocks occur in the San Andres, Oscura, Magdalena, Socorro, Lemitar, Los Pinos, and Ladrones Mountains, in the Joyita Hills, and in small areas in the low hills east and southeast of Socorro.

SEDIMENTARY ROCKS[1]

BLISS SANDSTONE

The Bliss sandstone of Cambrian age occurs in Socorro County in the San Andres Mountains, where it crops out along the eastern front of the range, and in the southern part of the Oscura Mountains. The formation consists chiefly of

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

Generalized Section of Sedimentary Rocks of Socorro County

System	Series	Formation		Description	Thickness (feet)
Quaternary				Sand, gravel, boulders and clay	0-300
Tertiary		Santa Fe formation		Sand, soft sandstone, gravel and clay	0-500
				Sandstone, shale and gravel	0-1,100
Cretaceous	Upper Cretaceous	Mancos shale and possibly later formations		Shale, drab and dark colored, carbonaceous in part, sandstone and coal seams	1,000-2,000
		Dakota (?) sandstone		Sandstone, yellow, brown and gray colored; some shale	0-140
Triassic				Sandstone and shale, red, lavender and gray colored	200-1,250
Carboniferous	Permian	Manzano group	Chupadera formation. (Formerly the San Andres limestone above and the Yeso formation below)	Limestone and gypsum, largely light gray and dark gray, in upper part. Gypsum, limestone, sandstone and gypsiferous shale in variegated colors in lower part. Top member of lower part massive yellow sandstone up to 200 feet thick	1,600-3,000
			Abo sandstone	Sandstone, in part arkosic, and shale; maroon, reddish brown and gray	400-1,200
	Pennsylvanian	Magdalena group	Madera limestone	Limestone, thick-bedded, bluish-gray, some shale and sandstone	300-1,000
			Sandia formation	Shale, limestone, sandstone and quartzite; chief colors bluish drab, black and gray	300-1,000
	Mississippian	Lake Valley limestone		Limestone, massive, coarsely crystalline in places, light colored, generally cherty in upper part	0-125
Devonian		Percha shale		Shale, black and gray, and slabby and nodular limestone	0-125
Silurian		Fusselman limestone		Limestone, white and dark colored	0-140
Ordovician		Montoya limestone		Limestone and chert in alternating thin beds in upper part; limestone, massive, dark colored in lower part	0-100
		El Paso limestone		Limestone, light colored	0-125
Cambrian		Bliss sandstone		Sandstone, hard, gray; some hematite-bearing quartzite	0-55
Pre-Cambrian				Granite, schist, etc.	

hard gray sandstone and some quartzite. At two places in the San Andres Mountains, where examined by the writer, the basal member consists of 1 to 2 feet of quartzite containing a large amount of hematite. The thickness in Sulphur Canyon is about 50 feet but at the north end of the range and in the Oscura Mountains it is 6 feet or less.

EL PASO LIMESTONE

The El Paso limestone belongs to the Ordovician system. It overlies the Bliss sandstone along the east front of the San Andres Mountains, and in the south part of the Oscura Mountains. The thickness is about 160 feet in Sulphur Canyon, 80 feet in Lava Gap, and 25 feet in the Oscura Mountains. The bedding is mostly slabby, and weathered surfaces are bluish gray with brownish-buff markings. Locally the medial beds are massive.

MONTOYA LIMESTONE

Above the El Paso limestone in the San Andres Mountains is the Montoya (Ordovician) limestone, which also occurs at the south end of the Oscura Mountains. The formation consists of an upper member of alternating thin beds of limestone and chert and a lower member of massive dark-colored limestone. A sandstone member occurs locally at the base of the formation. It has a total thickness of 90 to 175 feet in the San Andres Mountains and 40 feet or less in the Oscura Mountains.

FUSSELMAN LIMESTONE

The Silurian system occurs in Socorro County only in the San Andres Mountains, where it is represented by the Fusselman limestone. This formation is about 120 feet thick at Sulphur Gap and thins rapidly toward the northern end of the range. There are two members; an upper one of hard dark-colored massive limestone, and a lower one of fine-grained limestone which weathers nearly white.

PERCH & SHALE

Percha shale of Devonian age crops out along the east front of the San Andres Mountains, where it rests upon the Fusselman limestone. The basal beds are black shale, above which are layers of slabby and nodular limestone separated by gray shale. It is 75 to 90 feet thick.

LAKE VALLEY LIMESTONE

The Lake Valley limestone of Mississippian age, formerly called the Kelly limestone in this region, is present in several areas. It occurs in the San Andres Mountains resting on the Percha shale. It is the basal sedimentary formation in the Magdalena Mountains, where it is the principal host rock for the ore deposits of the Magdalena district. In the Ladrones Mountains the Lake Valley limestone rests on the pre-Cambrian in the vicinity of Cerro Colorado but seems to be absent elsewhere. This is the northernmost exposure of Mississippian rocks in New Mexico. The Lake Valley limestone apparently forms the base of the sedimentary section in the Lemitar Mountains, as the lowest beds are lithologically similar to this formation in the Magdalena Mountains and are overlain by a corresponding Sandia sequence.

The Lake Valley limestone in the Magdalena district consists of crystalline crinoidal limestone about 125 feet thick above a thin bed of quartzite. It contains a middle member of gray to black sub-lithographic slightly dolomitic limestone 5 to 10 feet thick called the "Silver Pipe." On the east side of the Magdalena Mountains the thickness is about the same, but the "Silver Pipe" bed is more variable and less prominent. In the Ladrones Mountains the Lake Valley limestone is somewhat thinner, and the "Silver Pipe" is absent. In the San Andres Mountains it is a massive bed of limestone 25 to 80 feet thick with no stratum corresponding to the "Silver Pipe."

MAGDALENA GROUP

Pennsylvanian rocks known as the Magdalena group are a prominent feature in the San Andres, Oscura, Los Pinos, Ladrones, Lemitar, Socorro and Magdalena Mountains, and in the hilly country bordering the Rio Grande valley east of Socorro.

Limestone is the predominant rock of the Magdalena group, but interbedded sandstone and shale occur in all sections. In most places in the county the formation is from 600 to 1300 feet thick, but in the San Andres Mountains it is about 2,000 feet thick.

In parts of New Mexico the Magdalena group has been divided into the Sandia formation below and the Madera limestone above, but the plane of division appears not to be constant. The stratigraphic position of the sandstone beds varies, and there are transitions from one member to another in different localities. In general the Sandia formation contains snore shale and less limestone than the Madera, and in places shale is the predominant rock.

ABO SANDSTONE

The Abo sandstone is of Permian age and is the basal formation of the Manzano group. Its outcrops occupy large areas in the San Andres and Oscura Mountains and in the ridges east of Socorro. An important area extends southwestward from the vicinity of Scholle, Valencia County, along the southeast flank of the Los Pinos Mountains, and another large area lies northwest of the Sierra Ladrones. Smaller outcrops occur in the Magdalena Mountains, in the Jornada del Muerto and near Cerro Venado.

The thickness of the Abo sandstone ranges from 400 to 1200 feet. Although most of the rock is slabby sandstone and arkose of maroon and reddish-brown color, considerable red sandy shale is included.

CHUPADERA FORMATION

The Chupadera formation, the upper member of the Permian Manzano group, rests upon the Abo sandstone. It was formerly divided into the Yeso formation below and the San Andres limestone above, and this classification is still valuable in places. The Yeso consists mainly of gypsum, limestone, soft sandstone and gypsiferous shale. In the eastern and central part of the county a massive yellow sandstone 50 to 175 feet thick is the top member. Usual colors are gray, yellow, pink and red. It is 1,200 to 2,200 feet thick, the greatest thickness apparently occurring at the Chupadera Mesa. The San Andres limestone is chiefly dark gray and light gray limestone, but gypsum beds in varying amounts are included. It has a thickness of 350 to 800 feet.

The Chupadera formation outcrops prominently in northeastern Socorro County, where the surface rocks of the Chupadera Mesa consists entirely of this formation, northwest of the Ladrones Mountains, in the hills east of Socorro, and on the west slope of the San Andres Mountains.

TRIASSIC ROCKS

The Chupadera formation is overlain in places in Socorro County by Triassic beds, consisting of gray, red and lavender sandstone and shale. These rocks vary greatly in thickness, ranging from 100 to 1100 feet. Triassic rocks crop out in a large area north of Puertecito in the northern part of the county, near Carthage, in the northern part of the Jornada del Muerto, and northeast of Socorro.

CRETACEOUS ROCKS

The Cretaceous system includes the Dakota (?) sandstone, Mancos shale, and possibly some Mesa Verde beds. The Dakota consists of up to 140 feet of yellow, brown and gray sandstone and subordinate shale. Drab and dark-colored shale the chief rock of the Mancos shale, but the formation contains numerous massive sandstone beds. The shale is commonly dark and carbonaceous. Several coal beds occur, and considerable coal has been mined in the vicinity of Carthage and Tokay. The formation has a maximum thickness of perhaps 2,000 feet. In the northwestern part of the county a large area is floored with Cretaceous rocks, and Cretaceous exposures are prominent in the hills bordering the east side of the Rio Grande from La Joya to Carthage.

TERTIARY ROCKS

Tertiary rocks belonging in part to the Santa Fe formation occupy large areas of the Rio Grande valley on both sides from near San Marcial to the north county line. They consist of sand, soft sandstone, gravel and clay, and in places have a thickness of 1,000 feet or more.

QUATERNARY ROCKS

Quaternary rocks consist of sand, gravel, boulders and clay. These rocks constitute the surface formation of the San Agustin Plains, Jornada del Muerto, Tularosa Valley, much of the Rio Grande Valley and in other areas. They are frequently called bolson deposits and consist of erosional products from the surrounding elevated land masses. The valley fill of the large basins, which consists of both Quaternary and Tertiary deposits, is surprisingly thick in places, amounting to as much as 2,000 feet.

INTRUSIVE ROCKS

Intrusive rocks of early Tertiary age have penetrated the earlier rocks at a number of places in the county. They take the form of stocklike bodies, dikes and sills, and in places are associated with ore deposits. The most prominent of these masses are stocklike bodies in the Magdalena district and the thick sill forming Salinas Peak in the San Andres Mountains. An intrusive mass exposed only underground occurs in the Socorro Mountains. A prominent dike associated with contact-metamorphic iron ores outcrops for several miles in the Chupadera Mesa, and there are a number of dikelike outcrops near Rayo. An intrusive mass is associated with contact-metamorphic iron ores north of Fairview and just within the boundary of Socorro County.

The intrusive rocks are largely monzonite or monzonite porphyry. Quartzose and granitic phases are locally present, as in the Magdalena district, and in the San Andres Mountains a wide dike of gabbro was noted.

TERTIARY AND QUATERNARY LAVAS

Extrusive rocks are largely confined to the mountainous areas west of the Rio Grande, but a few remnants occur east of the river. These rocks are divided into Quaternary basalt and a Tertiary andesite-latite-rhyolite series. The earliest flow seems to have been andesite, but rhyolite with associated tuffs generally forms the larger part of the series. Quartz latite and andesite are very important in the Magdalena district. A characteristic feature of these Tertiary lavas in Socorro County is the presence of numerous basic dikes, particularly in the Magdalena Mountains and in the southwestern part of the San Mateo Mountains. Rhyolite dikes are common in the Magdalena district, and a sill of rhyolite porphyry is exposed in the sedimentary area on the east front of the Socorro Mountains.

The extrusive period ended with relatively recent basalt flows, most of which rest directly on Quaternary gravels. Scattered remnants of these flows cap buttes and mesas at a number of places in the county. The most prominent of these remnants are the basalt mesa near San Marcial and the mass at San Acacia, both of which temporarily dammed the Rio Grande. Basalt is prominent at the southern end of the Socorro Range, and the vent from which this material came presumably lies in this vicinity. At the eastern edge of the county and extending into Lincoln County is a capping of basalt which seemingly is part of the same flow that forms the malpais occupying Tularosa Valley to the southeast. In the extreme northwestern corner are a few outliers of the extensive basalt area to the northwest in Valencia County.

STRUCTURAL FEATURES

Lindgren[1] states that the period of Tertiary igneous activity was accompanied by a general continental uplift, and that northward-striking dislocations outlining the principal ranges accompanied this crustal movement. In practically all places the main northward-striking dislocations are modified by minor transverse breaks. The transverse system is well illustrated in the Joyita Hills, although the displacement is not as great as in some other places.

In addition to the dislocations accompanying regional structural deformation, the intrusion of large masses of igneous rock has resulted in local structural modifications. Typical of this are many of the faults of the Magdalena district, which have developed in response to the thrusting action of the intruding monzonite. At Jones Camp the intruding dike has caused a sharp anticline.

Gordon[2] classifies the mountains of this area as follows: "(1) The tilted mountain, whose primary feature is due to displacement of a crustal block; and * * * (2) that resulting from accumulation of volcanic material." To the first type belong the Ladrones, Los Pinos, Oscura, and San Andres Mountains. These mountains are monoclinal blocks with a steep fault-scarp on either the eastern or western front and a gentle, approximate dip slope on the opposite face. Lindgren refers the formation of these monoclinal mountain blocks to faulting along a broad regional domal uplift, as already

[1]Lindgren, Waldemar, op. cit. (Prof. Paper 68), P. 26.

[2]Gordon, C. H., op. cit. (Prof. Paper 68), P. 221.

noted, but Darton[1] has shown that folding has been an important factor in their formation.

The San Andres-Oscura uplift is an example of the combined effect of folding and faulting. The Oscura Mountains have a fault-scarp western front and a gentle easterly slope. What appears to be a continuation of the fault zone cuts the southern foothills of the Oscura Mountains in the vicinity of Mockingbird Gap and forms an eastward facing fault scarp to the northern San Andres Mountains. This steep eastern face continues southward, and the sedimentary rocks of this range have a gentle monoclinal back slope to the west. The San Andres-Oscuro uplift thus seems to represent an anticline faulted at a slight angle to its axial line by a scissor-like action with the pivot in the vicinity of Mockingbird Gap.

The second type of mountain range as classified by Gordon is represented by the Datil and particularly by the San Mateo Mountains. The Magdalena, Socorro and Lemitar Mountains and the Joyita Hills are combinations of both types.

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[1]Dayton, N. H., op. cit. (U. S. Geol. Survey Bull. 794), pp. 77-87, 183-194.

HISTORY OF MINING IN SOCORRO COUNTY

Mining in Socorro County dates back possibly to the early Spaniards, since it is reported that ancient workings, presumably Spanish, were found in the Socorro Peak district when it was first prospected.[1] The important mining history of the county began with the discovery of the oxidized lead-silver ores of the Juanita mine in the Magdalena district by J. S. Hutchason[2] in 1866. Hutchason is said to have come to the region looking for rich float that had been found at Pueblo Springs a few years earlier.

The zinc ores of the Magdalena district were recognized and first mined in 1903.[3] Shortly afterward the deeper workings revealed large bodies of zinc sulphide ore accompanied by lead and copper sulphides, and concentrating plants were built to handle the ore. A smelter was built at Socorro in 1881 by Gustav Billing to treat ore from the Kelly mine, as well as custom ore. This smelter was acquired about 1901 by the American Smelting & Refining Co. and dismantled. Slag from the old dumps of this smelter has been shipped as flux to the El Paso smelter in recent years. The Graphic smelter at Magdalena was built in 1896, but it operated only intermittently until 1902.

Prospectors spread out from the Magdalena district, and in 1876 the Torrance vein in the Socorro Peak district was discovered by a man by the name of Hanson. At about the same time the ores of the Water Canyon district on the east side of the Magdalena Range were discovered. The earliest mining in this district is said to have been for silver and gold.

The Hansonburg copper deposits first attracted attention in 1872, and prospecting led to the discovery of the lead deposits of the district. Gold was discovered at Rosedale in the San Mateo Mountains in 1882, but the early mining enthusiasm was sharply checked by frequent incursions of the Apache Indians under Geronimo. During the same general period there was some excitement over the supposed discovery of important deposits at the "Negro Diggings" in these mountains, so named because they were operated by Negro soldiers from the old fort of Ojo Caliente.

The first statistical record of mining in the San Andres mountains is an assay report on copper ore from Grandview Canyon dated June 30, 1896, but the earliest work in these mountains undoubtedly antedated this by many years and was

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[1]Jones, F. A., New Mexico mines and minerals, p 111, 1904.
[2]Idem, p. 119.
[3]Lindgren, Waldemar, op. cit. (Prof. Paper 68), p. 242.

probably not long after the discovery of the Organ district[1] in Luna County in 1849.

The silver mines of the Socorro Peak district were shut down, except for annual assessment work and a little mining during periods of high silver prices, about 1895. The Rosedale mine closed in 1916. The Magdalena district continued important operation until 1920. Since then its production has been spasmodic though appreciable, and the district is still the most important in the county.

PRODUCTION

Up to July 1, 1921, Socorro County included within its boundaries what is now known as Catron County, and conse-ouently all production figures issued to that date included production from the Mogollon district. The annual volumes of "Mineral Resources of the United States" issued by the United States Geological Survey and the United States Bureau of Mines give production figures for the two counties as far back as 1904. Lindgren[2] gives production data for Socorro County from 1882 to 1903 taken from Reports of the Director of the Mint, but it is impossible to segregate Mogollon production from these figures.

Only three districts in Socorro County yielded an appreciable production prior to 1904. These were the Magdalena, Socorro Peak and Rosedale districts. Jones[3] estimates that production from the Magdalena district up to Jan. 1, 1904, was approximately $8,700,000. Brinsmade[4] gives the production for this period as $6,600,000. Production from the Socorro Peak district prior to 1904 has been estimated at from $760,000 to $1,000,000. No figures on the Rosedale district are available, but the production was probably some hundreds of thousands of dollars. On the basis of these figures, production from Socorro County prior to 1904 may be estimated at between $7,500,000 and $10,000,000. Probably the lower figure is more nearly correct. Scant figures of the output from the Billing smelter at Socorro are available, but it is impossible to estimate how much of this was produced from custom ores.

The accompanying table gives the annual production of metals in Socorro County from 1904 to 1928. Production of all metals for this period was valued at $21,975,609. It is estimated that the total production of the county to 1928 had a value of about $30,000,000.

Production in Socorro County during the late years of the preceding and the 'early years of the present century constituted an important proportion of the state's mineral output, but this

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[1]Jones, F. A., op. cit., p. 73.
[2]Lindgren, Waldemar, op. cit., (Prof. Paper 68), pp. 21-23.
[3]Jones, F. A., op. cit., p. 121.
[4]Brinsmade, R. B., Kelly, N. M.; A zinc comp: Mines and Minerals, vol. 27, pp. 49-53, 1900.

Production of Metals in Socorro County, 1904-1928[1]

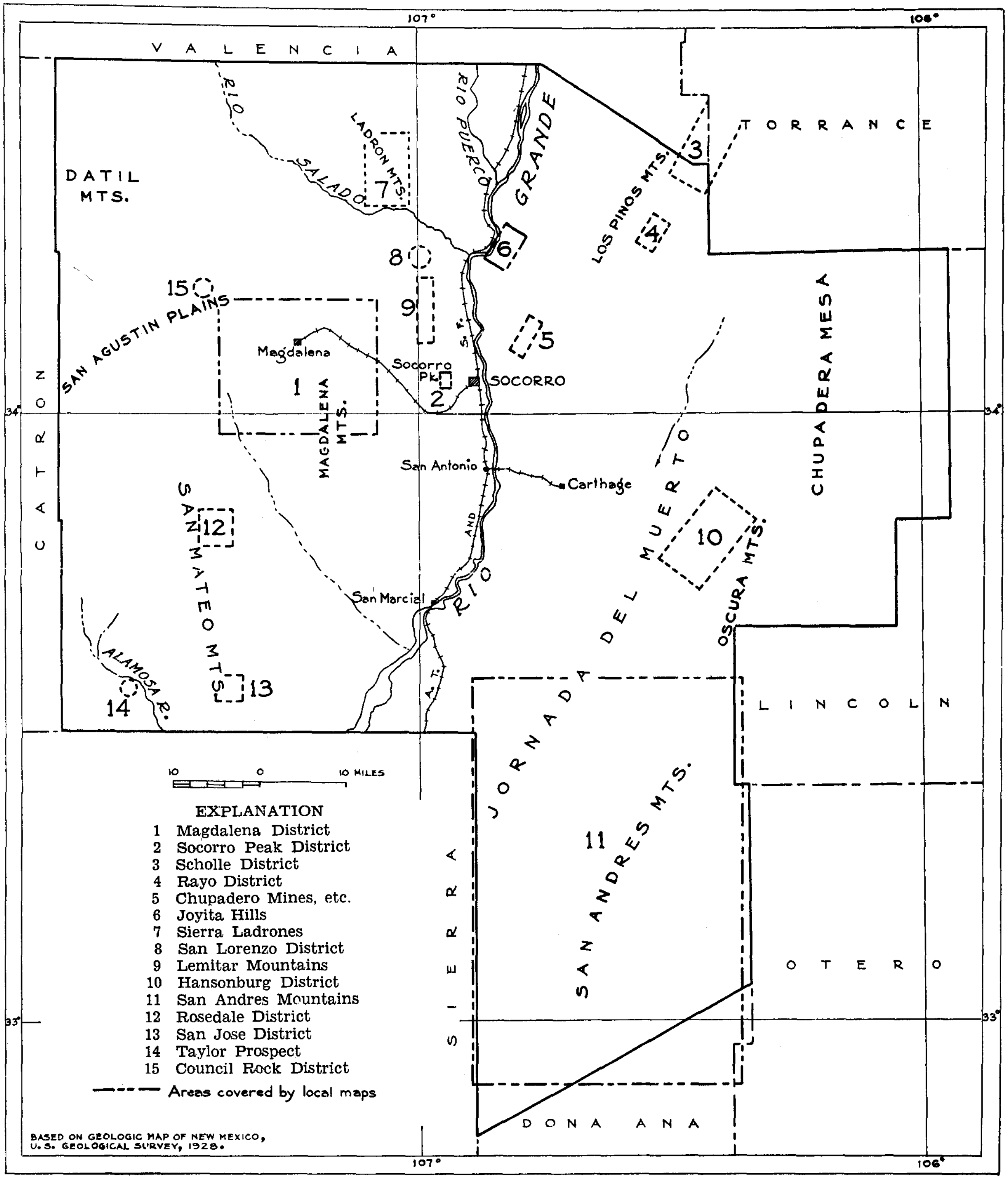
Year	No. of Producing Mines	Dry Tons	Gold		Silver	
			Ounces	Value	Ounces	Value
1904		33,989	1,925.11	$ 39,792	6,457	$ 3,745
1905		33,913	980.99	20,277	4,810	2,934
1906		34,465			2,515	1,710
1907		3,776	0.61	13	4,406	2,908
1908		9,302	990.42	20,472	1,152	611
1909		35,641	1,211.18	25,035	19,648	10,217
1910		59,014	334.01	6,904	66,331	35,819
1911		26,330	140.06	2,895	42,907	22,740
1912	8	22,669	37.30	771	33,281	20,468
1913	9	47,666	192.07	3,970	40,394	24,398
1914		51,595	109.58	2,265	14,436	7,983
1915		75,463	23.61	488	56,941	28,869
1916		78,814	99.51	2,057	73,228	48,184
1917	28	100,795	105.76	2,186	137,250	113,094
1918	16	56,495	20.80	430	49,976	49,976
1919	10	13,938	0.48	10	30,117	33,731
1920	5	17,235			18,367	20,020
1921	1	412			155	155
1922	3	8,304	10.00	207	6,156	6,156
1923	9	10,117	22.01	455	15,721	12,891
1924	6	11,128	9.63	199	10,643	7,131
1925	11	12,398	55.83	1,154	25,182	17,476
1926	6	43,414	29.32	606	14,575	9,095
1927	11	41,702	37.49	775	70,478	39,961
1928	8	6,798	95.79	1,980	16,183	9,467
Total		835,373	6,431.56	$132,941	761,309	$529,739

Year	Copper		Lead		Zinc		Total Value
	Pounds	Value	Pounds	Value	Pounds	Value	
1904	3,200	$ 410	688,209	$ 29,593	13,493,835	$ 688,186	$ 761,726
1905	320,000	49,920	390,000	18,330	14,630,051	863,173	954,634
1906	64,506	12,460	238,088	13,571	17,044,163	1,039,694	1,067,435
1907	38,645	7,729	707,981	37,623	676,356	39,905	88,078
1908	19,462	2,569	16,073	675	3,325,446	156,296	180,623
1909	170,792	22,203	3,085,279	132,669	12,878,241	695,425	885,549
1910	152,284	19,340	3,452,364	151,904	16,727,870	903,305	1,117,272
1911	77,448	9,681	2,123,039	95,537	9,930,281	566,026	696,879
1912	89,592	14,783	2,192,792	98,676	9,962,487	687,411	822,109
1913	285,148	44,198	2,198,030	96,713	13,267,811	742,997	912,276
1914	214,722	28,588	674,205	26,294	13,785,176	703,044	768,174
1915	1,416,098	247,817	2,031,297	95,471	18,437,218	2,286,215	2,658,860
1916	1,012,406	249,052	4,421,290	305,069	19,312,179	2,587,832	3,192,194
1917	2,699,333	736,918	4,885,210	420,128	14,716,745	1,501,108	2,773,434
1918	585,482	144,614	3,078,098	218,545	11,501,879	1,046,671	1,460,236
1919	599,382	111,485	819,566	43,437	2,995,740	218,689	407,352
1920	311,663	57,346	873,012	69,841	3,764,235	304,903	452,110
1921			60,711	2,732	133,000	6,650	9,537
1922	8,063	1,088	923,541	50,795	3,119,298	177,800	236,046
1923	50,388	7,407	1,506,829	106,478	3,421,000	232,628	358,859
1924	94,626	12,396	1,636,825	130,946	3,823,800	248,547	399,219
1925	83,300	11,829	2,444,600	212,680	3,170,000	240,920	484,059
1926	56,714	7,940	1,400,200	112,016	8,013,300	600,997	730,654
1927	173,817	22,770	1,637,667	103,173	4,430,000	283,520	450,199
1928	128,327	18,479	991,207	57,490	339,000	20,679	108,095
Total	8,655,452	$1,841,022	42,476,113	$2,629,286	222,899,111	$16,842,621	$21,975,609

[1]Compiled from "Mineral Resources of the U. S."

proportion quickly dropped with the development of the copper deposits in Grant County. The peak was reached in 1916 during the war period with 78,814 tons valued at $3,192,194. Although the tonnage in 1917 was approximately 28 per cent greater than the preceding year, its value was considerably less, owing to a lower price and decreased output of zinc, the principal metal produced. The metals stand in the following order in value of production: zinc, lead, silver, copper and gold.

The history of production in the county practically coincides with that of the Magdalena district from 1910 on, since this district has been responsible for nearly the entire production of the base metals and for a large proportion of the precious metals. From 1904 to 1928 inclusive the value of the production of the various metals in the Magdalena district constituted the following percentages of the totals for Socorro County : gold, 14.5; silver, 99.5; copper, 99.0; lead, 99.8; zinc, 98.8; total 98.6. During this period the value of the same metals produced in Socorro County represented the following percentages of the production for the entire state : gold, 0.86; silver, 3.33; copper, 0.88; lead, 34.0; zinc, 46.2; total 7.8.



MAP OF SOCORRO COUNTY
Showing location of mining districts

ORE DEPOSITS

GEOGRAPHIC DISTRIBUTION

There is no particular geographic distribution of ore deposits in Socorro County other than that they are confined to the mountainous areas. Neither is there any particular geographic distribution of the metals themselves, except possibly bismuth, which has been found only in the San Andres Mountains. Within individual districts, however, there is evidence of such distribution, as in the Magdalena, Water Canyon, Joyita Hills and Hansonburg districts.

GEOLOGIC DISTRIBUTION OF DEPOSITS

Among the ore deposits of Socorro County are represented many of the types classified by Lindgren[1] for the state of New Mexico. This classification is as follows:

1. Pre-Cambrian deposits.
2. Contact metamorphic deposits.
3. Veins connected with intrusive rocks of early Tertiary age, exclusive of replacement veins in limestone.
4. Copper deposits due to oxidizing surface waters.
5. Veins and replacement deposits in limestone exclusive of contact metamorphic deposits.
6. Veins connected with volcanic rocks of Tertiary age.
7. Lead and copper veins of doubtful affiliation.
8. Placers.
9. Copper deposits in sandstone.

The general remarks which Lindgren makes regarding the deposits of the state apply in large parts to those of Socorro County.

It is doubtful if any ore deposits in Socorro County are of pre-Cambrian age. There are many deposits in pre-Cambrian rocks but their later formation is clear in most cases. The copper deposit in Sulphur Canyon in the San Andres Mountains may possibly be of pre-Cambrian age, but it is probably contemporaneous with the other deposits on the east slope of the San Andres Mountains. Deposits of the type of Class 3 do not seem to be represented. Class 4, copper deposits due to oxidizing surface waters, may be considered represented by the disseminated ore in the monzonite of the Magdalena district, but the actual enrichment by copper has been inconsequential. Placer deposits are practically absent.

The deposits of Socorro County, with the possible exception of the Sulphur Canyon deposit, are probably all related to the period of Tertiary igneous activity so widespread not only in New Mexico but

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[1]Lindgren, Waldemar, op. cit. (Prof. Paper 68), pp. 47-48.

throughout the southwest. Many of the deposits are unquestionably related to this activity. Lindgren[1] includes the deposits of the Joyita Hills and the copper deposits of the San Andres Mountains among the veins of doubtful affiliation. More detailed work, the necessity of which was pointed out by Lindgren, has removed most of the early doubts.

In practically all cases except the "Red Beds" deposits, the location of ore bodies has depended on some structural control. Even in the replacement bodies in limestone, as exemplified in the Magdalena district, faulting and fracturing have played a major part, although the importance of selective replacement of wall rock is obvious. In other limestone deposits, specifically the Hansonburg district, prior silicification has sealed off the rocks, and the deposits of valuable minerals represent open-space filling to a very great degree. Open-space filling has been almost the only process of vein formation in granite and in volcanic rocks.

GEOLOGIC DISTRIBUTION OF METALS

The deposits of Socorro County contain a considerable variety of metals. Gold, silver, copper, lead and zinc have been produced in commercial quantities. In addition to these, iron ore occurs in certain deposits which under favorable economic conditions would be of commercial importance. Ores of bismuth, tungsten and vanadium also occur in the county. It is possible that tin also may be present in the San Mateo Mountains in an extension of the Taylor Creek district.[2]

In a general way it may be said that in Socorro County ores of the base metals occur in sedimentary rocks, commonly limestone, whereas ores of gold and silver occur in the volcanic rocks. On the other hand, veins in volcanic rocks carry ores of copper, lead and zinc where these rocks are within the sphere of influence of some intrusive mass. The deposits in limestone are commonly argentiferous, and most of the silver production of the county has come from these deposits.

FUTURE POSSIBILITIES

Generalizations as to the future possibilities of the deposits of Socorro County cannot be made safely at the present stage of development. Mineralization is decidedly widespread in the county, but most surface exposures are unpromising. Perhaps it is significant that so many of the deposits herein described seem characteristic of deposition by attenuated solutions. This suggests the possibility of larger mineral bodies at depth, but prospecting for such possible ore bodies requires considerable capital and courage. It probably will be

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[1]Lindgren, Waldemar, op. cit. (Prof. Paper 68), P. 74.

[2]Lanky, 8. CO., and Wootton, T. P., The metal resources of New Mexico and their economic features: N. Mex. Sch. of Mines, State Bur. of Mines and MM. Res. Bull. 7, (in preparation).

years hence, if ever, before any other district in the county will rank with the Magdalena district. The future possibilities of each district are treated separately.

MINING DISTRICTS

MAGDALENA DISTRICT

The geology and ore deposits of the Magdalena district have been discussed by C. H. Gordon[1]. Recently the district has been studied by geologists of 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. A comprehensive report on the geology and ore deposits of the district is in preparation, which will be published by the United States Geological Survey.

The following description of the Magdalena district is taken from the manuscript of Bulletin 7 of the State Bureau of Mines and Mineral Resources of the New Mexico School of Mines entitled "The Metal Resources of New Mexico and Their Economic Features," by S. G. Lasky and T. P. Wootton.

The Magdalena district is in the Magdalena Mountains, from which it takes its name. The district is near the north end and chiefly on the west slope of the mountains. 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

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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. 241-258, 1910.

& 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 1928 was $21,835,712, in zinc, lead, copper, silver and gold. The value of the entire production from the discovery of the district to 1928 was about $28,400,000.

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, which is 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. These rocks are chiefly limestone, but considerable interbedded shale and some quartzite are present. The Magdalena group is separated into the Sandia formation below and the Madera limestone above. The Permian Abo sandstone overlies the Magdalena group in places. It consists of sandstone and shale.

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. Local sulphide segregations are present which contain essentially pyrite and sphalerite with a little chalcopyrite and a trace of galena. Pyroxene, amphibole and chlorite are prominent in the outer part of this zone, and sulphides are more abundant. Garnet is present locally. The high-temperature ores grade southward into typical sulphide replacement bodies. Galena and, to a lesser extent, chalcopyrite become increasingly more prominent 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 inner sulphide zone but is most abundant beyond the limits of intense mineralization. Fluorite is occasionally present and may be abundant in the outlying parts of the district. Primary ore deposition probably occurred in Tertiary time.

Near the surface secondary or oxidized ores derived from the primary ores occur. During oxidation the lead and zinc were segregated in 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. Some of the smithsonite is the ferriferous variety, monheimite.

AREA SURROUNDING THE MAGDALENA SPECIAL QUADRANGLE

GENERAL FEATURES

Figure 1 shows the location of the principal prospects in the territory immediately surrounding the area covered by the Magdalena Special Quadrangle of the United States Geological Survey and the northward and westward extensions thereof as surveyed by A. H. Koschmann and M. W. Black of the State Bureau of Mines and Mineral Resources of the New Mexico School of Mines for the forthcoming report on the district by the United States Geological Survey in co-operation with the State Bureau of Mines and Mineral Resources. (See page 33.)

The character, composition, and distribution of the different rock formations, structural relationships, and the topography of the region are similar to these features in the area covered by the Magdalena quadrangle. Basic dikes are common, but with one minor exception they bear no evident relationship to mineralization. The dikes cut the veins in places, but elsewhere they stop abruptly against the veins or are cut by them in turn.

With the exception of the veins at Cat Mountain, the deposits group themselves in a zone running northwest through Kelly and Magdalena, seemingly a local transverse concentration of metallization within the northeast-southwest belt in which the mining districts of the state are located.[1]

The deposits contain a variety of metals and may be grouped into four classes: (1) Precious metal deposits in Ter-

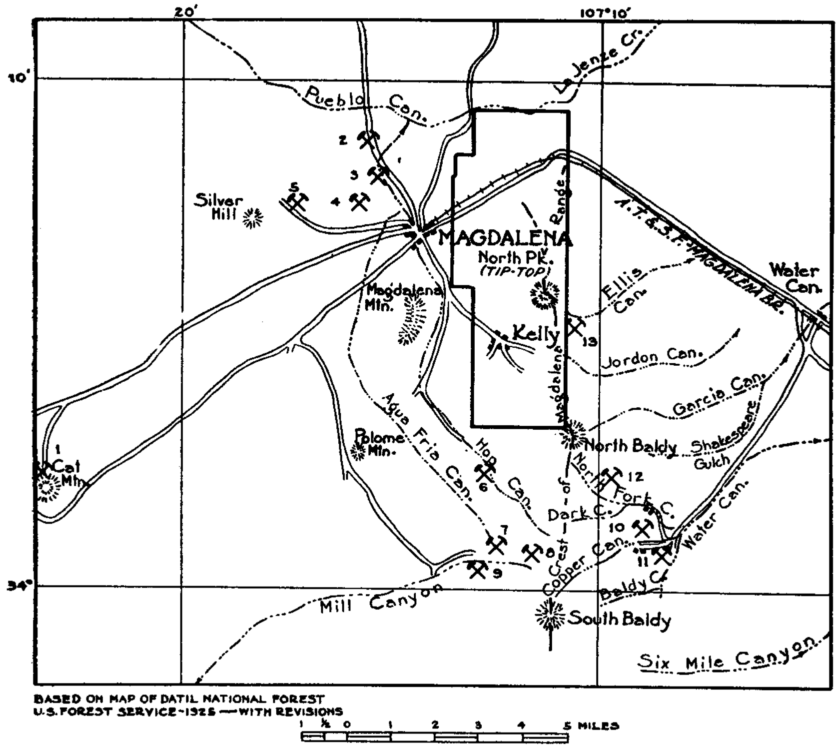

Figure I.—Index map showing location of the principal prospects in the area surrounding the Magdalena Special Quadrangle, which is shown by the heavy line. 1, Colorado-Justice claims; 2, Pennsylvania group; 3, Jack Frost and Night Hawk groups; 4, Pleasant View group; 5, Copper Belt Silver & Copper Mining Co. property; 6, Hop Canyon district; 7, Cuprite (Wheel of Fortune) mine; 8, Iron Cap vein; 9, Old Soldier vein; 10, Hall-Lytton property; 11, Buckeye mine; 12, Nutter lease; 13, Ellis Canyon prospect.

tiary volcanic rocks, (2) veins of lead and of lead and vanadium in volcanic rocks with an occasional showing of copper, (3) deposits of copper and silver in volcanic rocks, and (4) replacement deposits in limestone of lead and silver with subordinate zinc and copper. The ore minerals include native gold, galena, sphalerite, chalcccite, chalcopyrite, covellite, argentite, chrysocolla, malachite, cuprite, native copper,

[1]Lindgren, W., op. cit. (Prof. Paper 68), p. 46.

goslarite, anglesite, cerusite, plumbojarosite, vanadinite and descloizite. The chief gangue minerals are quartz, calcite, aragonite, barite, fluorite and iron and manganese oxides.

But little systematic exploration or mining has been done in this area; in the main, rich pockets have been gouged out with obviously no attempt to develop the more meager portions. Surface cuts and shallow test pits are very abundant. Most of the important workings are either full of water or caved, so that it has been impossible to verify a number of reports.

Small shipments have been made from some of the properties from time to time, but the production is unimportant.

CAT MOUNTAIN

Cat Mountain is an island of Tertiary lavas within the alluvium about 13 miles by road southwest from Magdalena. In plan the outline of the mountain resembles a sleeping cat.

COLORADO-JUSTICE CLAIMS

The Colorado-Justice group of claims is in the low northwest foothills of Cat Mountain. A road to the workings branches off from U. S. Highway 60 about 9 miles west of Magdalena. It is in good condition throughout. This group of claims has not been worked since 1903,[1] but assessment work is being kept up by one of the owners.

Judging from the size of the dumps, considerable prospecting has been done through vertical shafts on three veins which outcrop on the gently rolling, timbered foothills. One shaft has two compartments. Near it are the remains of an old steam engine and a 20-stamp mill.

The veins, which outcrop in andesite and rhyolite, have short and inconspicuous exposures. They strike N. 50°-60° E. and dip 80°-90° NW. According to reports they converge with depth. Gold is the only metal of interest, and quartz and calcite are the chief gangue minerals. Basic dikes earlier than the veins are common. Fragments of basic dike rock are found on all the dumps.

No conclusion as to the possibilities of this prospect can be drawn because of the inaccessibility of the workings for detailed examination. According to a private report an average of the assays of 58 samples, taken from outcrops and underground workings, was $6.85 a ton, chiefly in gold. An assay of a sample of material taken by the writer from under the stamps gave returns of 0.06 oz. gold and 0.46 oz. silver a ton. These last figures may be assumed representative of the value of the ore that was being mined at the time the mill shut down. It is possible that the value of the ore as mined failed to equal that

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[1]Jones, F. A., New Mexico Mines and Minerals, p. 125, 1904.

indicated by sampling, a condition which is so frequently the cause of failure in mining. Jones[1] says that operation was stopped because of an inability to save the valuable metals, the inference being that the ore contains an appreciable amount of metal which might be extracted by more efficient metallurgical treatment.

NORTH MAGDALENA DISTRICT

The North Magdalena district includes a number of claims and prospects in the volcanic rocks just northwest of Magdalena. Nearly all the veins have long outcrops and seem to be of the shear-zone fault-contact type. The ores contain copper, lead, zinc, vanadium, gold and silver.

COPPER BELT SILVER & COPPER MINING CO PROPERTY

Location and ownership.—The Copper Belt Silver & Copper Mining Co. owns a group of 13 claims 2 ½ miles a little west of north from Magdalena on the east slope of Silver Hill. The company was incorporated in Colorado in 1919.

Geology.—The claims cover the extensive outcrops of two steeply dipping, intersecting fissure systems which strike N. 25° W. and N. 50° W., respectively. The outcrops, although not prominent, are easily followed. A third system, striking southwest, is less well exposed. Figure 2 is a claim map of the company's holdings showing the vein systems. The country rock is predominantly andesite, but quartz latite occurs in places. Possibly the Lake Valley (Kelly) limestone, Sandia formation and Madera limestone are present beneath the Tertiary lavas.

Workings.—A considerable number of test pits, cuts and shallow shafts have been opened on the various veins. The main shaft, a two-compartment, well timbered opening, is 300 feet deep. Water was struck at about 200 feet. Two drill holes which have been put down to investigate the supposedly underlying limestone bottom at 825 feet and 1,020 feet respectively, both still in igneous rocks.

Mineralogy.—The ore minerals include chalcocite, covellite, argentite, chrysocolla, and malachite. Quartz is the chief gangue mineral. Limonite is present in the more highly oxidized parts of the vein. Calcite, though generally absent, is locally abundant.

Chrysocolla, which is the youngest mineral, is most abundant, but argentite may be more important commercially. Locally there is considerable malachite and granular orthorhombic chalcocite. A small amount of covellite always occurs with the chalcocite as the first product of oxidation, in places in megascopic quantities.

Argentite is associated with the chalcocite and its oxida-

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[1]Idem.

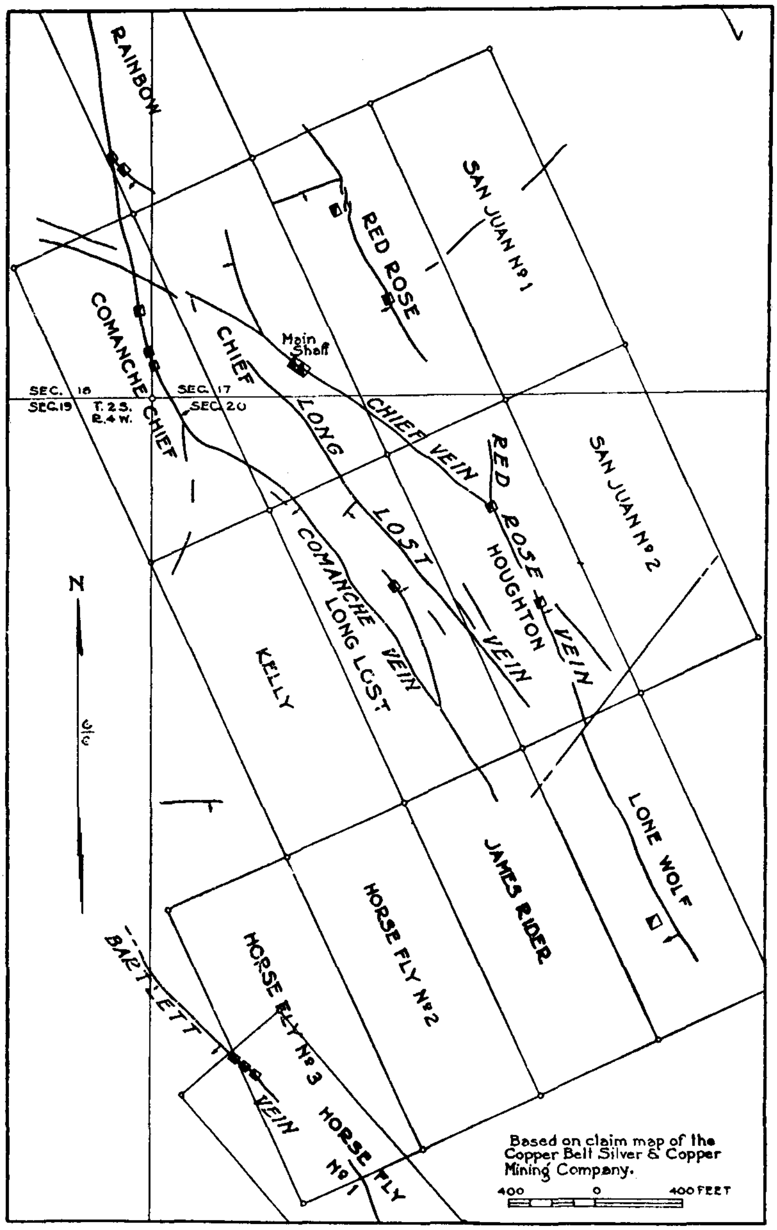

Figure 2.—Claim map of the Copper Belt Silver & Copper Mining Co. property showing vein systems.

tion products. The argentite is indistinguishable from some of the chalcocite on the clean polished surface under the microscope, and only by etching with HNO_3 or KCN does it become exposed. Normally it is unrecognizable by the unaided eye in these ores, but the polished surfaces of specimens of highly oxidized ore reveal minute though visible residuals of argentite and also a few small areas of covellite and chalcocite which have escaped complete oxidation. (See Plate II, A.) Each speck of argentite lies within a matrix of malachite surrounded by a shell of limonite. Veinlets of chrysocolla cut the malachite and limonite, the malachite being completely replaced in places.

The number of minute residuals of argentite in the highly oxidized ore suggests a more abundant supply of this mineral than is visible in the chalcocite even at the highest available magnification. The argentite may have been contained within the chalcocite in particles of submiscroscopic size, possibly in solid solution. An interesting feature is the absence of native silver, the presence of which would be expected if the argentite were a replacement of the chalcocite.[1] The appearance of the specimens is suggestive of oxidation and solution of the chalcocite, grain by grain, with almost instantaneous neutralization of the solution. If the dissolving solutions were rapidly neutralized, as suggested, they would perhaps have had an opportunity to extract only the most soluble material, and as oxidation progressed some of the less soluble argentite may have migrated inwardly and together, finally to form a visible particle if enough were present within the grain.

The Ore.—The ore occurs in small pockety shoots within the veins. Mineralization, consisting of the filling of fissures and breccia openings in andesite and quartz latite, seems to have been independent of the chemical nature of the host rock. The location of the ore shoots appears to have been controlled by the amount of fracturing. The best showing of ore is on the Chief vein. The main shaft is on this vein, and ore is reported in the bottom at a depth of 300 feet. The lower part of the shaft is under water. At a depth of about 100 feet a drift along the vein exposes a thin stringer a few feet long of copper silicates. Good ore is exposed on the Red Rose vein and on a number of the smaller fractures. A small amount of ore has been extracted and shipped from the larger outcropping oreshoots. Small lots are said to have contained several hundred ounces of silver to the ton.

Possibilities.—Because of the small amount of work done the possibilities of this prospect can be only a matter of con-

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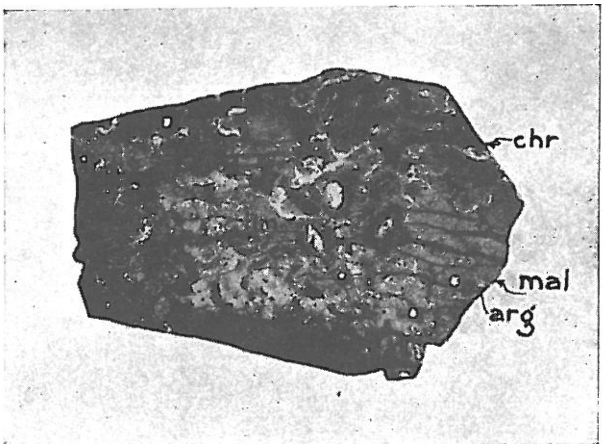
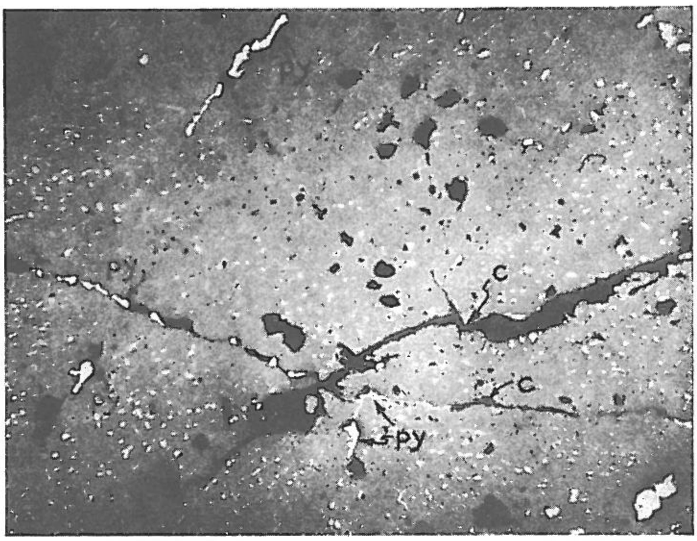
[1]Palmer, C., and Bastin, E. S., Metallic minerals as precipitants of silver and gold: Econ. Geol. vol. 8, pp. 140-170, 1913.

The precipitation of native silver from silver solutions by chalcocite is so delicate that the reaction is used as the basis of a method for the determination of the comparative presence of cuprous and cupric ions in certain mixtures of the two. (Econ. Geol., vol. 10, p. 503, 1915.)



A. POLISHED SPECIMEN OF OXIDIZED COPPER ORE FROM COPPER BELT SILVER AND COPPER MINING CO. PROPERTY.—Enlarged 2 diameters.

cv, residuals of covellite with a little intergrown chalcocite; arg, residuals of argentite presumably left behind on complete oxidation of the copper sulphides; mal, malachite; lim, rings of limonite which have developed around centers of oxidation; chr, late veinlets of chrysocolla



B. PHOTOMICROGRAPH OF ORE FROM NUTTER LEASE, NORTH FORK CANYON. WATER CANYON DISTRICT.—Enlarged 100 diameters.

Inclusions of chalcopyrite (white dots and rods) in sphalerite (gray background), with late veinlets of pyrite (py) and calcite (c) jecture at present. The ore in sight indicates only a moderate degree of mineralization. However, since the andesites are not particularly favorable for copper deposition, the exposures of ore cannot be taken as indicative of the total mineralization which may be present. The chalcocite suggests secondary transportation from a previous source, and there is thus a possibility that ore shoots larger than those already exposed may be found within the volcanic rocks. Such shoots could have derived their content of both copper and silver not only from the original source but also from the secondary ore shoots now exposed, all of which show advanced oxidation.

The zone of fissuring is extensive in strike, and even at a very moderate ratio of length to depth some of the fissures might be expected to cut the underlying limestones if these are present. The effusive rocks are not readily mineralized, and sufficient mineral matter to form a workable deposit may have reached the limestone from above, unless the limestone lies at such depth that much of the ore may have been dissipated in small pockets before reaching it.

If some underlying igneous body, perhaps related to the intrusives at Kelly, is the primary source of the copper and silver, as is probable, there is a somewhat greater chance of ore at the deeper and more favorable horizons.

JACK FROST AND NIGHT HAWK GROUPS OF CLAIMS

Location and ownership.—The Jack Frost and Night Hawk claims are contiguous but separately owned groups located for the most part on the same vein in the island of volcanic rocks about 2 ½ miles north of Magdalena on the road to Riley. The Jack Frost group of eight claims is owned by A. Dugger, and the four claims of the Night Hawk group, which adjoin the Jack Frost claims to the east, are owned by P. B. Moore. Some of the claims are on state land.

History.—According to reports, shipments were made by ox teams from these claims in the early days of the district to the smelter at Socorro and to the old Pennsylvania mill in Pueblo Canyon. During the period from 1925 to 1927 a small amount of concentrates was marketed by N. L. Brown of Albuquerque. No work was in progress in July, 1929.

Geology.—The predominant rocks of the area are andesite and quartz latite. Basic dikes are numerous, and in many places they form one or both of the vein walls.

The main vein, called the Jack Frost vein, strikes about N. 80° W. and dips 65°-80° to the north. It is constant in strike but irregular in dip. Eastward it breaks up into a number of divergent stringers which finally join with a vein that at this place strikes N. 50°W. and dips 70° NE. The second vein is much less strongly mineralized although somewhat longer. To the northwest the strike of this vein swings in a gentle arc to N. 30° W.; to the southeast it gradually pinches and dies out about a quarter of a mile from the junction of the two veins.

Workings.—The veins have been prospected by numerous shallow shafts, cuts and pits. The only important working is on the Jack Frost vein and consists of a shaft about 140 feet deep. Drifts aggregating about 105 feet in length have been driven on four levels. The shaft is inaccessible below a depth of 30 feet because of bad timbering. The hoist house is still standing, and adjacent to it are the dismantled remains of a steam power plant and of a concentrating plant.

Ore Deposits.—The Jack Frost vein follows a brecciated fault contact and is from 6 to 9 feet wide. Barite, calcite and galena fill the breccia interstices and replace the fragments. Locally there is a little fluorite. To the north the vein contains considerable quartz and some incrustations of vanadinite, but sulphides are absent. A little cerusite may appear with the galena. Copper mineralization is reported to occur in a half-inch streak on the hanging wall at the bottom of the main shaft. A few specimens stained with copper carbonate were found on the dump.

About 225 feet east of the main shaft is a shaft 10 feet deep. A stringer 6 inches wide containing some galena and chalcopyrite occurs a few inches within the hanging wall of the main vein, but the vein itself is devoid of sulphides. The miners consider this to be the same shoot that appears in the shaft. Farther east a small amount of chalcopyrite appears with galena and barite in the main vein.

Vanadinite appears as incrustations confined almost entirely to that part of the vein in which quartz latite forms at least one of the walls. Descloizite is scattered throughout much of the outcrop. Galena is more prominent within andesite walls or where andesite breccia is abundant within the vein. Wherever a basic dike forms one of the walls it presents a sharp contact, and mineralization is confined to the andesite side. Showings of galena occur for more than a mile along the vein. At a few places there has been sufficient concentration of this mineral to constitute ore.

PLEASANT VIEW GROUP

One mile south of the Jack Frost group is the Pleasant View vein upon which a well-timbered shaft has been sunk to a depth of 90 feet. Water was struck at 60 feet, and the shaft is inaccessible. The vein strikes about due north and dips to the east. The country rock is a white rhyolite having a suggestion of flow structure.

A pile of good ore on the dump consisted chiefly of galena, quartz, barite and vanadinite. The owners, one of whom is A. Dugger, report that the best vanadinite ore occurs at and just below water level. They report that 12 tons of this vanadinite ore will produce one ton of concentrate containing 14 per cent of vanadium pentoxide and 64 per cent of lead. A concentrate with this analysis would be exceedingly high grade, as pure vanadinite, according to one of the formulae given in Dana's Textbook of Mineralogy,[1] contains 19.4 per cent vanadium pentoxide and 73.1 per cent lead. According to Hess,[2] it is usually difficult to raise the content of vanadium ores by concentration much above 8 per cent vanadium pentoxide.

A small body of lead ore has been mined on another vein trending N. 35° W. The galena has a peculiar purple tarnish which, at a cursory glance, gives it the appearance of covellite. The claim covering this vein is patented.

PENNSYLVANIA GROUP

One mile north of the Jack Frost group and near the road from Magdalena to Riley is the Pennsylvania group of claims. A narrow shear zone in white rhyolite and quartz latite strikes N. 20° E. and dips 75°-80° SE. At one place this shear zone is crossed by a basic dike, and near the south end it seems to follow the contact between a basic dike and the quartz latite. The shear zone is traceable for about a mile. Visible mineralization is similar to that described for the other veins in this area but is slight. The numerous workings consist of pits, shafts and tunnels. It is reported that the vein was originally worked for gold. At one time a stamp mill in Pueblo Canyon treated the ore from these claims.

HOP CANYON

Hop Canyon is on the west side of the Magdalena Range about midway between North Baldy and South Baldy. It heads at the crest of the range and has a course of about N. 40° W. The following description of the geology is by Gordon

> In its lower portion the slopes of Hop Canyon are occupied mostly by rhyolite and rhyolite tuffs and breccias. Andesite tuffs and breccias appear wherever the overlying rhyolite has been cut through by erosion. * * * Dikes of basic rock cut the rhyolite in different directions.

Prospecting has been done on both sides of the canyon but chiefly on the southwest side.

HOP CANYON PROPERTY

The abandoned workings of the Hop Canyon Mining and Smelting Co. are near the head of the canyon. The road to the

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[1]Ford, W. E., Dana's textbook of mineralogy, 3d ed., p. 599, 1922,

[2]Hess, F. L., Vanadium ores and metals. Chapter in Marketing of metals and minerals, edited by Spurr, J. E., and Wormser, F. E., p. 207, New York, McGraw-Hill Book Co., 1925.

[3]Lindgren, W., Graton, L. 0., and Gordon, C. H., The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, p. 258, 1910.

property is in good condition except for the last half mile where it follows the canyon bottom. A trail continues to the top of the range. Workings consist of open cuts, shafts and adits.

The property was examined by Gordon[1] in 1905, at which time prospecting operations were being vigorously conducted on a shear zone which strikes about N. 10° W. and dips about 70° SW. A long adit was run into the southwest side of the canyon to crosscut the main vein about 500 feet below the outcrop, but the vein at the intersection was tight and no ore was found, although assays are said to have given results in gold.

Apparently little work has been done since Gordon's visit. The writer's examination in July 1929 did not reveal the presence of any workable ore deposits nor was any ore observed in the part of the main adit open to inspection.

CALUMET & NEW MEXICO PROPERTY

Down the canyon from the Hop Canyon property and adjoining it to the northwest is the property of the Calumet & New Mexico Mining Co., likewise abandoned. Prospecting operations seem to have consisted of driving two adits, one on each side of the canyon. These adits are caved, but judging from the size of the dumps each of them is probably several hundred feet long.

KERY PROSPECT

A few hundred feet farther down the canyon and adjoining the Calumet & New Mexico claims is the Kery prospect. An adit in the southeast side of the canyon has been driven S. 30° W. through alluvium into andesite breccia. Its length is about 100 feet. Some good copper sulphide specimens in a little pile at the mouth of the adit and a few rounded pebbles showing copper carbonate stain were observed, but no ore is exposed in the workings. An attempt by the writer to find an outcrop on the slope above the adit was unsuccessful.

MILL CANYON

Mill Canyon heads just south of the head of Hop Canyon at the crest of the Magdalena Range, which at this place has an elevation well over 10,000 feet. In general its course is about S. 80° W. A road, the last two miles of which are exceedingly rough, leads to Riviere's cabin, about one mile from the head of the canyon and 13 miles from Magdalena.

IRON CAP VEIN

An oxidized outcrop of a silicified shear zone in andesite and rhyolite is exposed on the north side and near the head of the canyon at an elevation of about 9,650 feet. This zone is about 14

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[1]Idem

feet wide. No sulphides are visible in the outcrop, but there are traces of pyrite, chalcocite, covellite, and malachite at a depth of about 35 feet below the outcrop in a 100-foot adit which was driven to cut the vein. The first work on this vein was done in 1926. The prospect, known as the Iron Cap, is owned by August Riviere.

CUPRITE OR WHEEL OF FORTUNE MINE

At the Cuprite or Wheel of Fortune mine a good body of copper ore has been mined near the surface. The deposit is on the north side of the canyon, about a mile west of the Iron Cap workings and 200 feet lower in elevation. According to Gordon,[1]

> On the east side of Mill Canyon a considerably body of cuprite has been opened close to the surface in the Wheel of Fortune mine. It occurs in a fissured zone about 24 feet wide running N. 20 -25 W. The country rock is called "birdseye porphyry" by the miners. This rock is an andesite with large phenocrysts of plagiocise in a ground-mass composed chiefly of small laths and grains of feldspar and a sparing amount of ferromagnesian constituents. * * * The copper appears as a replacement of the shattered porphyry, which has suffered a great deal of alteration along the vein. Its present concentrated form is apparently due to oxidation and secondary enrichment. Very little work had been done on the property at the time of visit (1905) and no conclusion as to the extent of the ore body could be drawn.

Since Gordon's visit the ore body has been almost entirely worked out. It contained a notable amount of covellite which is generally present in only insignificant quantities in the copper deposits of New Mexico. The ore remaining occurs in fractures in the shattered rock as chalcocite, covellite, malachite, and chrysocolla with a trace of residual primary chalcopyrite. A few specimens containing free gold and said to have come from the more oxidized part of the deposit were shown to the writer, but none of this material could be found in place. The bottom of the workings, at a depth of about 75 feet, still shows in places narrow stoping widths of mill ore, mostly copper carbonate and silicate. A basic dike cutting the orebody shows films of copper carbonate along the joints. The ore shoot seems to have been a pipelike body about 50 feet long, 10 to 25 feet wide, and at least 75 feet deep.

An adit has been driven along a fault to cut the expected downward extension of the vein at an estimated depth of 450 feet. Swelling and caving ground along the fault near the portal gave so much trouble that the adit was driven only 625 feet, about 250 feet short of where it was thought the Cuprite vein would be cut. The face is reported to be in hard rock.

Before 1919 about 300 tons of ore are said to have been shipped to smelters at Douglas, Ariz., and El Paso, Tex., which returned between $700 and $900 a car. The ore contained 6 to 9 per cent of copper and $6.00 in gold per ton.

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[1] Idem

OLD SOLDIER VEIN

The Old Soldier vein crosses the canyon about a quarter of a mile below Riviere's cabin. It strikes northwest and dips steeply to the northeast. Mineralization occurs in a sheeted zone about 25 feet wide in andesite. Calcite, the chief gangue mineral, which is black with manganese oxides, has completely replaced the original rock in places. A small amount of galena occurs with the calcite.

The vein has been prospected on both sides of the canyon. The main workings are on the south side and consist of approximately 1,000 feet of shaft, drifts and crosscuts. Most of the openings have caved. In the shaft a few feet below the surface is a small stope about 20 feet in diameter from which a little ore was extracted. A crosscut adit a little below the outcrop served as a haulage way for drawing ore from this stope. Assessment work is being kept up in this adit. The vein is said to be cut off in the shaft by a westward-dipping fault at a depth of about 225 feet.

WATER CANYON DISTRICT

LOCATION AND AREA

The Water Canyon (Silver Mountain) district is on the east side of the Magdalena Range. It adjoins the Magdalena district on the southeast and includes within its boundaries the highly faulted southward extension of the sedimentary rocks of the Magdalena district. The prospect at the head of Ellis Canyon is included within this district. Some of the roads are in good condition, but others need considerable repair. The district has a small production to its credit.

GEOGRAPHY

Water Canyon, from which the district receives its name, has a course of about N. 30° E. It is fed by a number of branch canyons from the west, notably North Fork and Copper Canyons, and thus drains that portion of the eastern slope of the Magdalena Mountains between South (Big) Baldy and North (Little) Baldy Peaks. North Fork Canyon heads on the south slope of Little Baldy; Copper Canyon heads on the north slope of Big Baldy. According to Jones[1] the first claims were located in 1868, contemporaneously with the early locations on the Magdalena side of the range.

GEOLOGY

Structurally, the Water Canyon district consists of westward-dipping Mississippian and Pennsylvanian strata lying on a basement of pre-Cambrian argillite ("greenstone") and overlain by Tertiary Volcanic rocks. Pre-Cambrian granite is not exposed.

[1]Jones, F. A., New Mexico mines and minerals, p. 126, 1904.

Faulting by northward- and eastward-striking faults (approximately strike and dip faults) is present, and displacement has resulted in tilted blocks, causing a repetition of formations.

In common with the rest of the area around the Magdalena district, basic dikes striking in different directions are prominent features. There are also a number of rhyolite porphyry dikes with a general northward trend. The average strike of the strata is a few degrees west of north, and the dip about 35° west in general conformity with the strike and dip of the strata to the north. However, the area has been strongly block faulted so that locally the attitude of the contact between the argillite (locally known as "greenstone" and "schist") and the overlying Lake Valley (Kelly) limestone may vary greatly from the regional strike and dip.

The ores in the limestone contain lead, copper, and zinc, and minor amounts of silver. They occur most commonly at intersections of channels of access with certain favorable horizons within the Lake Valley limestone. Deposits of lead-zinc ore have also been found in the upper part of the Madera limestone where is it faulted against rhyolite. Gold and silver veins in the volcanic rocks have been prospected along the higher slopes to the south and near the top of Little Baldy. According to C. T. Brown[1] early mining in the district was for silver and gold. A small amount of copper occurs in the andesite in North Fork Canyon.

DISTRIBUTION OF METALS AND OUTLOOK

Mineralization in Copper Canyon is of lead and zinc. In North Fork Canyon copper and lead are the important metals, accompanied by zinc at one place in the higher part. Copper is widespread throughout North Fork Canyon. The traces of this metal which appear so commonly in the volcanic rocks on the south slope seem associated with the basic dikes. The rest of the copper mineralization shows no evidence of such relationship. In the one occurrence of zinc in North Fork Canyon the copper appears as dots and dashes of chalcopyrite in sphalerite.

The copper mineralization extends at least as far east and south as the spur between Copper and Water Canyons, where the Buckeye mine is situated, and extends northward to Ellis Canyon where a small amount of chalcopyrite is associated with the galena. North of North Fork Canyon lead is the predominant metal.

In the volcanic rocks on the higher slopes of the district the valuable metals are silver and gold, but metallization seems sparse. Mineralization of the base metals throughout the district, as exposed

[1]Private report.

by the present surficial workings, is moderate but promising to the small miner without large overhead. Small shoots of ore are fairly abundant, and it is believed that others in addition to those already worked can be found without prohibitive expenditures. Larger bodies of ore are not beyond a reasonable expectancy.

HALL-LYTTON PROPERTY

The ore deposits on the Minerva group of claims, known as the Hall-Lytton property, are typical of the lead-zinc replacement bodies in the Water Canyon district so that a detailed description of these claims will illustrate the general type of deposit and the local problems involved in prospecting for them.

The 18 claims known as the Minera group are owned by Messrs. Hezekiah Hall of Magdalena and Lee Lytton of Fort Worth, Tex. These claims cover the outcrop of the Lake Valley limestone between Copper and North Fork Canyons. (See Fig. 3.) Both North Fork and Copper Canyons follow fault zones. The block between these canyons appears to have been elevated with respect to the areas north and south, the result being that in those areas the Kelly limestone outcrop lies to the east.

The first claims of the Minerva group were located in 1880. The two claims know as the Balakhana and Balakhana No. 1, to the south of the Minerva group, are patented claims held by Mr. Hezekiah Hall.

Workings.—The greatest amount of work has been done in Copper Canyon. On the Minerva No. 1 the north slope of the canyon is penetrated by about 1,500 feet of workings. The tunnel, which was started along a rhyolite porphyry dike, follows the "Silver Pipe" bed for a short distance and then a basic dike. The underlying "greenstone" contact and the overlying shale contact were explored by crosscuts from the tunnel and by winzes erratically placed. Water was encountered in the winzes about 6 feet below the level of the drift. A few specks of galena show in the limestone along the dike, and a crosscut in the north end of the workings passes through about 10 feet of slightly mineralized limestone under the shale.

Work on an ore body about 65 feet below the level of the Minerva tunnel under the south end line of the claim had to be stopped because of water.

On the North Fork Canyon side of the ridge, on the Minerva No. 11 claim, is a shaft 30 feet deep from which extends, in a southeasterly direction, a ramification of workings totaling about 700 feet. These workings were begun on the "Silver Pipe" limestone. They also prospect the "greenstone" and shale contacts to a small extent.

There are a few other shallow shafts and short adits on the property and two short drill holes.

Production.—The ore body about 65 feet under the Minerva Tunnel yielded 40 tons of ore upon which the smelter re turns were 0.01 oz.

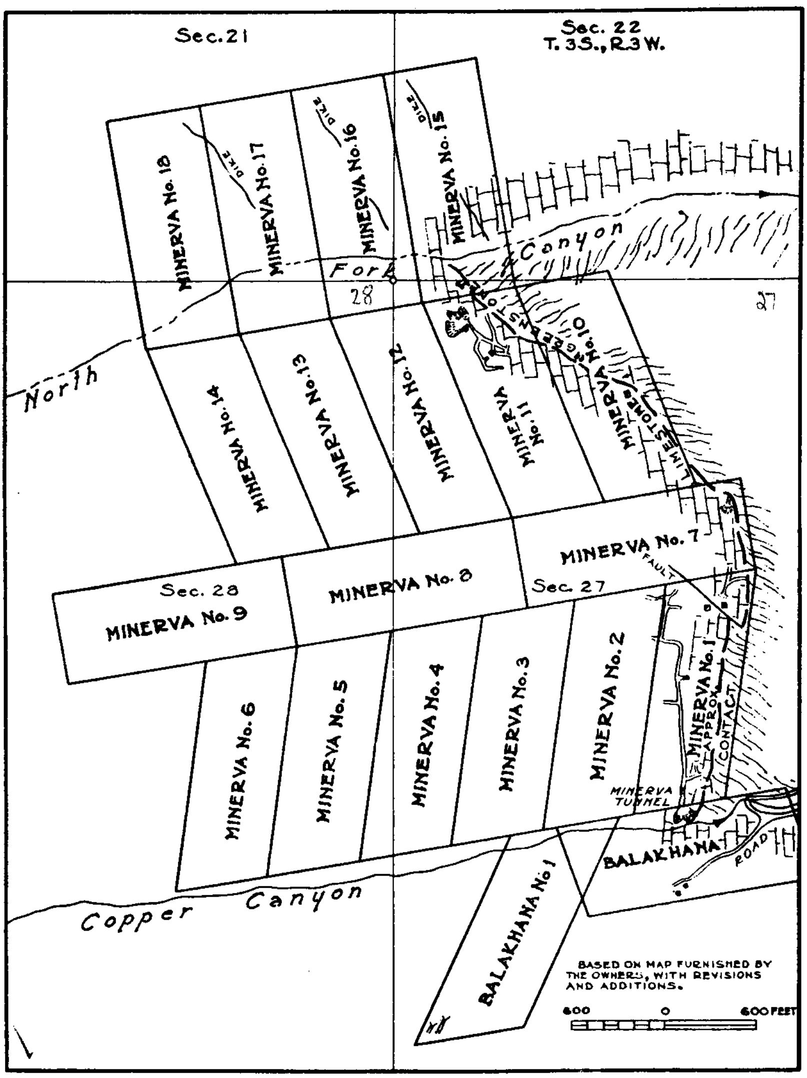

Figure 3.—Map of the Hall-Lytton property in Water Canyon showing relation of claims and workings to the limestone-"greenstone" contact.

gold, 0.80 oz. silver, 22.0 per cent of zinc, and 12.1 per cent of lead. This body is about 60 feet below water level and is now flooded.

It is reported that there is still ore in sight, but that work was stopped because of the water.

Ore has been shipped from a lens of galena-sphalerite ore about 8 feet in diameter and 4 feet thick below the shale about two-thirds of the way up the ridge from the Minerva Tunnel. A lens of lead ore about 12 feet by 3 feet by 4 feet was extracted from farther up the hill at the point of the ridge but at a lower stratigraphic horizon. About a mile up North Fork Canyon 15 tons of ore was extracted in 1917 from a stope at the shale contact on the Minerva No. 11 claim. The smelter returns were 0.04 oz. of gold, 16.6 oz. of silver, 16.9 per cent of lead, and 3.4 per cent of copper, and the shipment netted $322.00. The stope is fairly large and considerably more than 15 tons were extracted from it, but much of the material was too low grade to ship.

Ore Deposits.—Four favorable horizons similar to those in the Magdalena district to the northwest have been found within the Lake Valley limestone. These are : (1) At the limestone-"greenstone" contact, (2) below the "Silver Pipe" bed, (3) above the "Silver Pipe" bed, and (4) below the shale which is the basal member of the overlying Sandia formation. These four horizons lie within a thickness of strata of not more than 100 feet. The "Silver Pipe" bed, as exposed on the Minerva group of claims, is from 6 inches to 7 feet thick. It lies about 45 feet above the "greenstone" and about 35 feet below the basal shale of the Sandia formation. The "Silver Pipe" bed in this area does not exhibit the marked stratigraphic difference from the overlying and underlying crystalline limestone which is characteristic in the Magdalena district but seems to grade laterally and above and below into crystalline limestone. Elsewhere the contact is sharply defined at bedding and joint planes.

The ore deposits have formed at the intersection of some channel of access with one or more of these horizons. The channel through which the ore-bearing solutions reached the favorable host rock is plainly visible at each body of ore that has been found. The outcrop of a quartz vein containing a little copper carbonate and much limonite was found on the Minerva No. 11 claim. A body of good silver-lead-copper ore was found underground at the contact of this fissure with the impervious shale. In the same tunnel a little ore containing copper, lead and silver was extracted from on top of the "Silver Pipe" bed at its contact with a fissure no wider than a knife blade. A winze was started on the ore but was stopped at water level with ore still in sight. The narrow fissure should connect a little above the tunnel level with the fissure leading to the ore body at the shale contact.

On the Copper Canyon side of the ridge the chief ore minerals are galena and sphalerite, and copper minerals are absent.

On the North Fork Canyon side of the property, however, sphalerite is absent and the ore minerals are galena, chalcopyrite, and subordinate sooty chalcocite and covellite. Pyrite is present in all the ore and is locally abundant. Small quantities of the oxidized products of the primary minerals are common.

Possibilities.—Two obvious and pertinent facts stand out in connection with these deposits. First, all the ore bodies so far encountered were found by accident; second, the significance of the channel of access and its relation to the location of the orebodies have not been understood.

The reputation of the "Silver Pipe" bed, gained in the Magdalena district, has influenced all local prospecting and probably to an undue extent. In spite of the known occurrence of ore at the limestone-greenstone and limestone-shale contacts in the Magdalena district, these contacts were never systematically prospected in the Water Canyon district.

Where ore has been found at the intersection of a fissure with one of the favorable horizons the possibilities are good that the intersections of this fissure with one or more of the other favorable horizons also may be orebearing. The average of the orebodies already found seems to be about 20 tons of $30 ore. Ground water presents an obvious but not necessarily prohibitive difficulty.

It is probable that an igneous source from which the ore-bearing solutions were derived underlies this area, as none is visible nearby. Considering the comparatively large number of small ore bodies associated with minor fractures which have acted as channels of access, it appears that there may be larger bodies at greater depth nearer the probable source.

The fact that the ore body below the Minerva No. 1 south end line lies somewhat below water level has been taken by local miners to indicate that the best opportunities for commercial ore lie below water. This ore body lies along the "green-stone" contact with the usual relationship to a channel of access, and its position with reference to the water level is fortuitous. In this connection it should be borne in mind that secondary sulphide enrichment of lead and zinc is rare. A slight silver enrichment is possible here at water level although in the body just referred to the silver content was negligible. In North Fork Canyon the water level may offer some slight possibilities for secondary enrichment of copper. The presence of sooty chalcocite in the Minerva No. 11 ore body signifies that a certain amount of enrichment has already taken place.

BUCKEYE MINE

The Buckeye mine is between and near the junction of Water Canyon and Copper Canyon at an elevation about 150 feet lower than the Minerva Tunnel. Work was suspended in

1901[1] because of the difficulty of handling the water. Some additional work was done in the vertical shaft in 1917, but no real progress was made. In addition to the vertical shaft, which is 300 feet deep, there is an incline shaft on the ore. The workings are flooded and inaccessible.

Copper is the chief metal. Fragments of ore on the dump show pyrite, chalcopyrite, chalcocite, carbonates, cuprite, and native copper. The ore occurs in silicified Lake Valley limestone above the "greenstone," the limestone-"greenstone" contact striking about N. 58° E. and dipping 46° SE. This anomalous attitude is due to faulting. An associated mineralized fault fissure is clearly exposed.

WALL STREET MILL

The ruins of the mill of the Wall Street mine are close to the Buckeye shaft. Remaining fragments of machinery show that equipment consisted of a jaw crusher, rolls, a Huntington mill, and tables. According to Jones[2] this mill was erected in 1903 and was designed to treat by amalgamation the oxidized ore from the Wall Stret group.

TINGLEY PROSPECT

The Tingley prospect lies up Copper Canyon about a mile from the Minerva Tunnel. It is on the south side of the canyon at an elevation of about 8,150 feet. Adits, crosscuts and winzes with an aggregate length of about 500 feet penetrate the hill for about 450 feet in a general southward direction. These openings explore contacts in a fault complex which exposes limestones, rhyolite, andesite, and basic dikes. Quartz, calcite, pyrite and limonite are abundant along these contacts. The valuable metal is said to be silver.

NUTTER LEASE

Mr. E. Nutter controls a number of claims on the higher - slopes of North Fork Canyon west of the Minerva group. The claims are owned by Messrs. Stewart and Brown of Magdalena.

Weak copper mineralization is prevalent throughout the canyon. A number of fracture zones on the south slope in andesite and rhyolite show copper stain which is usually faint. These zones have a northerly strike. Basic dikes are in contact with most of these showings. A little chalcopyrite was found in one of the dikes.

In a branch draw on the north side of North Fork Canyon a pipelike shoot of ore occurs in altered limestone at the intersection of two faults which strike N. 20° E. and N. 90° E. respectively. The latter carries good ore for at least 15 feet from the intersection, which is the length of the prospecting tunnel.

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[1]Jones, F. A., New Mexico mines and minerals, p. 126, 1904.

[2]Jones, F. A., op. cit., p. 128.

The ore appears to be mainly sphalerite and galena, with subordinate chalcopyrite and pyrite. The chalcopyrite occurs as microscopic dots and dashes in the sphalerite. (See Plate II, B.) Some of the galena is the steely variety; much of it is coarsely crystalline. Some of the crystalline galena has a purple tarnish.

The owners report a shipment in 1927 of 40 tons which contained 20.5 per cent zinc, 20 per cent lead, and 13.5 oz. silver a ton. The lack of a report on copper is surprising in view of the chalcopyrite which is present. About 25 tons of ore is piled up on the dump. It is reported that at least 100 tons of ore is in sight, but the bottom of the pit from which the ore was gouged is full of water so that this estimate could not be verified. Mining was stopped because of the difficulty of marketing with profit ore containing nearly equal amounts of zinc and lead.

Farther up the branch draw a tunnel was being driven at the time of the writer's visit to cut at an estimated depth of 300 feet a vein which outcrops on the hill above. The vein is 18 to 30 inches wide and contains galena in a gangue of barite in a vertical sheeted zone along the contact between quartz latite and what appears to be a wide rhyolite porphyry dike. In July, 1929, the tunnel was in about 235 feet and at that point had penetrated the rhyolite porphyry for about 175 feet. Three stringers of galena in the porphyry, varying in thickness from a small fraction of an inch to two inches, had been cut by the tunnel. The ore had been stoped from the outcrop to a depth of 100 feet, and the bottom of the stope was said to be still in ore.

Compressed air was used in driving the tunnel, power being supplied by a 6-cylinder automobile engine. Six men were employed.

ELLIS CANYON PROSPECT

A body of good lead ore near the head of Ellis Canyon on the east side of the Magdalena Range was being worked by Victor Papa at the time the district was visited. It is at an elevation of about 9,060 feet. The distance to Water Canyon Station by trail and road is about 7 ½ miles.

The ore occurs in silicified Lake Valley limestone as a replacement along bedding planes. The strata at this place strike N. 8° W. and dip 34° SW. The ore shoot is 2 to 3 feet thick and pitches N. 38° W. at an angle of 16°. Ore has been mined to a width of 6 to 15 feet, and some has been left on the walls. Two prospect adits on the same stratum as the ore shoot, both about 25 feet from the shoot and on opposite sides, disclose the characteristic ore minerals in small quantities.

The ore minerals include galena, chalcopyrite, cerusite, malachite, anglesite and plumbojarosite, and the gangue is largely calcite, aragonite, quartz, pyrolusite and barite. Anglesite is particularly ablindant. It contains many residual nuclei of galena, and in part has altered to cerusite. The galena carries stringers of chalcopyrite, a small amount of which has altered to malachite. Plumbojarosite is common as brown and yellow golden flakes and powder.

The ore shoot has been explored by an inclined shaft parallel to the pitch for a distance of 250 feet. Short drifts have been driven from the incline. At the bottom the shaft has been sunk vertically for a distance of 8 feet. The low slope of the incline permits the ore to be hauled out with a wheelbarrow drawn by a burro. Ore for shipment is carried by burros for about 4 miles to Strozzi's ranch, thence by truck to Water Canyon Station.

The smelter sheet for a sample shipment of 4,200 pounds of ore sent to the smelter at El Paso, Tex. in May, 1929, shows 5.8 oz. silver per ton, 52.8 per cent of lead, and 3.5 per cent of zinc. About 20 tons of ore was piled up awaiting shipment.

MAGGIE MERCHANT CLAIM

The Maggie Merchant claim, from which small shipments of ore have been made, lies a short distance up Shakespeare Gulch (Maggie Merchant Canyon). The smelter sheet for a shipment of 4,468 pounds to the El Paso smelter in December, 1927, shows the following assays: 0.9 oz. gold and 12.2 oz. silver per ton, 48 per cent of lead, and 1.07 per cent of copper. A 20-ton shipment is reported for 1925.

The ore occurs as a narrow vein of galena, sphalerite, chalcopyrite and their oxidation products along the contact between a basic dike and Lake Valley limestone and also as thin sheets following the bedding planes above the "Silver Pipe" bed. Two shoots along the bedding planes have been worked. In one of them a small wedgelike apophysis of the dike appears, and a thin stringer has been gouged out at the peak of the wedge and for a few feet along its limbs, saddle-reef-like, seemingly as deeply as could be reached with a pick. Native gold is said to have been associated with the galena in this stringer.

OTHER PROSPECTS

Many claims are located as gold-silver prospects on the higher slopes in the volcanic rocks, both to the north and to the south. The Timber Peak Mining Co. attempted to operate a stamp mill on gold-silver ore in this section in the early days of the district.

COUNCIL ROCK DISTRICT

The Council Rock district is about 12 miles northwest of Magdalena, near the edge of the volcanic rocks which constitute the

Datil Mountains. The various workings were known as the Cabinet mine, Deaf Reed mine, and the Boss mine. The veins of the district were worked in the early eighties, and nothing is known of the production. The ores are said to have consisted essentially of lead carbonate with considerable silver and a little gold.

The principal workings consist of a shaft said to be about 400 feet deep which is near the southeast end of the main vein. Other workings on this vein include cuts, pits, short adits, and shafts. The vein, which strikes about N. 35° W. and is nearly vertical, is traceable for about a mile. It follows a marked shear zone which is strongly brecciated locally. The vein matter as now visible consists mainly of glassy quartz with some barite locally. A trace of galena and copper carbonate stain were noted. The outcrops at places are strongly stained with manganese. The country rock consists of rhyolite porphyry and quartz latite (?).

A short, somewhat dissimilar vein occurs in white rhyolite about a quarter of a mile north of the main vein. It is about 3 ½ feet wide and consists of fragments of breccia cemented by calcite, barite, fluorite, quartz, in part amethystine, and a trace of galena. Some of the calcite is manganiferous and black. A few shallow shafts have been sunk on this vein.

THE JOYITA HILLS

GEOGRAPHY

The Joyita Hills consists of a granite core between westward-dipping Pennsylvanian and Permian strata and Tertiary volcanic flows. They 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 hills lie mostly in T. 1 N., R. 1 E., but extend about a mile south of that township.

Roads reach the area from La Joya and San Acacia on the western side of the range. On the eastern side an old road enters the northern end of the hills from the old main highway which is about 2 miles from the foot of the range. Roads at one time led as far as some of the prospects, but they have been neglected, and at the present time automobiles can not travel farther than the foot of the hills.

In the granite area, which is the highest topographic feature, the hills rise about 700 feet above the Rio Grande to the west and about 400 feet above the narrow plain to the east. They are jaggedly cut by many arroyos with sharp intervening ridges. The area is drained by two or three major arroyos which drain westward across the trend of the hills toward the

Rio Grande. These are fed by numerous small arroyos which are winding and irregular in the granite but tend to follow the stratification in the volcanic and sedimentary areas.

GEOLOGY

THE ROCKS

Pre-Cambrian rocks, which cover an area approximately 3 ½ miles long by one-fourth to three-fourths of a mile wide, form the core of the range. These rocks are chiefly coarse granite, consisting of quartz and pink feldspar, which locally grades into biotite gneiss. At most places the gneiss is reddish in color and coarse grained. So far as was determined the foliation of the gneiss has a northward strike and an eastward dip. Numerous aplite and pegmatite dikes are present in an unoriented pattern.

Sedimentary rocks adjoin the pre-Cambrian to the west. Beds of the Magdalena group lie at the base of the sedimentary section in contact with gneiss and granite. At the base of the Magdalena group is a bed of quartzite about 30 feet thick, varying in color from white to pink and in texture from coarse to fine. At the Bachelder-Everheart prospect at the north end of the granite area a lens of silicified limestone containing an abundance of well-preserved fossils lies within the quartzite about 2 feet above the gneiss contact. The gradation from quartzite to silicified limestone is through a thin layer of highly fossiliferous conglomerate. The lens dies out a short distance south of the prospect and passes under the overlying strata to the north and down the dip. Overlying the quartzite is a bed of black carbonaceous shale which appears to be about 40 feet thick. Cherty limestone overlies the shale. Corals which Professor Charles Schuchert has kindly identified as Chaetetes milleporaceus were found near the base of this limestone.

Darton[1] describes the sedimentary section as follows:

> At the north end of the area the limestone of the Magdalena group is exposed pitching under the Abo sandstone, but at the south end the relations are hidden by sand and gravel. • • • The red sandstone of the Abo formation, about 800 feet thick, forms a line of ridges or knobs, with soft beds of the lower member of the Chupadera formation Just west. These lower beds comprise 400 feet of reddish shale and soft red sandstone with some included limestone beds but no gypsum. Next above is soft red sandstone grading upward into massive gray sandstone, mostly hard, with two thin beds of limestone. This sandstone is overlain by limestone, the usual top members of the Chupadera formation. These upper sandstones and limestones, about 700 feet in all, constitute a zone of ridges and knobs of considerable prominence extending all along the west side of the uplift. The limestone extends northward to Arroyo Cibola, where it pitches below the Abo formation, and this in turn is covered by sand, gravel, and the Tertiary igneous succession. There is no evidence of its extension in Agua Torres, and the isolated knob of granite 6 miles east of La Joya is due to a separate uplift.

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[1]Darton, N. H. "Red Beds" and associated formations of New Mexico: U. S. Geol. Survey Bull. 794, pp. 84-85, 1928.

East of the granite ridge the underlying rocks are covered by a belt of Tertiary rhyolite flows and tuff and on the south by basalt. The volcanic rocks form low rounded ridges, parallel to the general trend of the range, with intervening arroyos which follow the pseudo-stratification.

STRUCTURAL RELATIONSHIPS

The eastern boundary of the pre-Cambrian area is marked by a low but sharply ridged eastward-facing escarpment, which is characterized by deeply grooved and slickensided surfaces. This escarpment marks the fault contact between the pre-Cambrian area and the Tertiary volcanic rocks to the east of it. The contact strikes northeastward and dips toward the southeast. The granite footwall is broken by vertical joints approximately at right angles to the fault. The general dip of the volcanic rocks is westward, but adjacent to the fault the dip seems to be reversed.

The contact of the pre-Cambrian with the sedimentary rocks on the west side of the hills is an erosional unconformity similar to this contact in the Magdalena district and elsewhere in the state. It has been slightly obscured by topographic conditions. An arroyo roughly follows the contact. It has cut its way along the yielding shale and in most places has completely stripped away the quartzite below to expose the underlying granite in slopes which are parallel to the dip of the associated sedimentary rocks. These rocks strike about N. 30° E. and dip 40° NW.

The contact has been broken by transverse faults, and quartzite is found resting on top of the granite and gneiss in some of the faulted blocks where erosion has not progressed sufficiently to remove it. Transverse arroyos in these blocks clearly expose the normal unconformable nature of this contact, dipping parallel to the overlying strata. The areas where quartzite is still exposed represent the relatively depressed blocks.

A strong fault which strikes about N. 60° W. and dips 75° to 80° NE. is exposed along Arroyo de Ojo del Padre not far north of the granite area. This fault has displaced the strata approximately the full thickness of the Abo formation, bringing the top of the Abo in the hanging wall almost directly opposite the bottom of the Abo in the footwall. The fault is visible from this place for several thousand feet and probably could be followed still farther.

ORE DEPOSITS

CHARACTER

The ore deposits of the Joyita Hills are chiefly fissure veins. In the west part of the area some of the ore occurs as open-space filling and as a replacement in a lens of silicified limestone within the basal quartzite of the Magdalena group. Galena poor in silver is the chief ore mineral. In common with occurrences elsewhere in this climate, the galena on exposure quickly becomes coated with a film of anglesite and may easily be overlooked in an outcrop. A small amount of copper mineralization, which includes chalcopyrite, malachite, chrysocolla, bornite, chalcocite and covellite, has been found at two places. The gangue minerals include fluorite, barite, quartz and iron oxides.

DISTRIBUTION

The deposits show a distinct spacial relationship to the pre-Cambrian rocks. (See fig. 4.) No ore has been found in

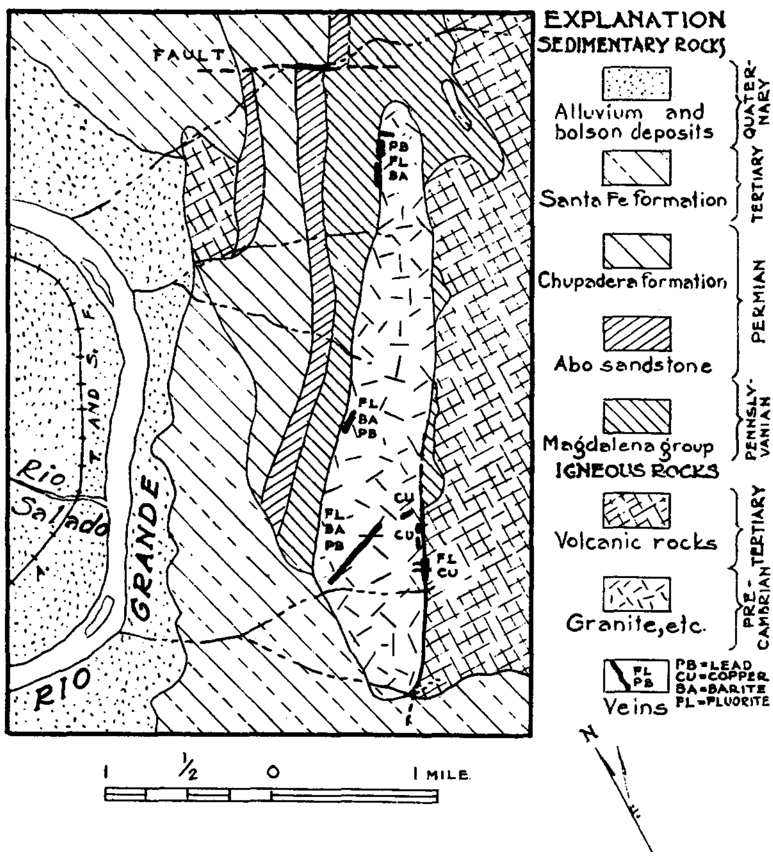

Figure 4.-Geologic map of the Joyita Hills showing distribution of mineralization and its relationship to the pre-Cambrian rocks. Based in part on reconnaissance geologic map of part of central New Mexico, by N. H. Darton (U. S. Geol. Survey Bull. 794, P1. 17).

either the sedimentary or volcanic rocks more than a few feet distant from the contact with the pre-Cambrian. So far as could be determined this relationship seems to be due to structural control. Mineralization apparently occurred in Tertiary time contemporaneously with and also slightly following the faulting which exposed the granite core. Fracturing of the rock incident to faulting presumably took place much more strongly within the narrow tongue of granite than within either the sedimentary or volcanic rocks, and these fractures offered the easiest passage to mineral-bearing solutions.

The ore-bearing silicified limestone lens within the quartzite was fractured parallel to the bedding but apparently without the more massive quartzite being greatly disrupted, thus offering a locus for deposition slightly outside the granite area but formed by the same fundamental disturbance as the fractures in the granite. The overlying limestone was probably dammed off from the mineral-bearing solutions by the intervening shale which also may have acted as a cushion against the stresses.

Fluorite occurs in all the deposits. It is specially prominent at the southern end of the area where the veins were prospected for this mineral instead of for their metallic content. Barite is present in most of the veins but usually in subordinate quantities, and it appears to be absent altogether in the southeast part of the mineralized area where copper mineralization is present. Galena is more abundant on the western side of the area and increases along this side to the north where a deposit has been worked for this mineral.

BACHELDER-EVERHEART PROSPECT

LOCATION AND GEOLOGY

In 1915 J. H. Bachelder and T. B. Everheart did some work on a lead prospect about 7 miles by road a little east of south from La Joya. The prospect is near the north end of the granite at an elevation of about 5,100 feet.

The deposits are near the contact of the pre-Cambrian rocks with the overlying strata of the Magdalena group. Thin patches of the basal quartzite remain on the granite and both contacts of the overlying shale are exposed in the walls of the arroyo. The cherty limestone which lies above the shale is well exposed on the west side of the arroyo. The shale contains thin partings of gypsum near the limestone. A lens of silicified limestone of undetermined size occurs in the quartzite about 2 feet above the gneiss.

ORE DEPOSITS AND WORKINGS

The main vein outcrops along the slope of the arroyo in the gneiss and is approximately parallel to the strike of the adjacent sedimentary rocks. The dip is to the northwest and gradually steepens from 30° near the top of the ridge to 36° and then abruptly to 50° near the contact. A lens of ore about 70 feet long and 2 ½ feet thick at the center occurs at the more abrupt change in dip. A shaft was sunk at a favorable place on the slope and struck the ore at a depth of about 40 feet. The ore is crystalline galena in a gangue of coarsely granular fluorite and barite. Banding is clearly shown. An adit was started at the bottom of the arroyo and was driven toward the shaft for a few feet.

Banded ore is exposed along the slope in the limestone lens in the quartzite just south of this adit. The banding is parallel to the stratification. A few hundred feet north of the shaft ore occurs as open space filling along a transverse fault. Gangue minerals constitute most of the vein filling at this place. Fluorite is abundant as colorless cubes, and banding is poorly developed. Many of the fracture planes in the gneiss and granite in the immediate vicinity have been prospected on showings of ore hut to no appreciable depth.

On the west side of the arroyo a shaft has been sunk for about 30 feet parallel to the bedding in carbonaceous shale at the limestone contact. This shaft was probably sunk in search of coal as there is no evidence of any other kind of deposit.

THE MILL

A poor road leads from the mine to the ruins of a concentrating mill about a quarter of a mile away in the first arroyo east. The equipment of the mill included a crusher, rolls, trommel and a Wilfley table. The treatment was unsuccessful, as the amount of crushing necessary to reduce the granite, siliceous limestone, and quartzite which was unavoidably broken with the ore, slimed the friable galena, and it could not be saved on the table.

JOYITA PROSPECT

A small amount of prospecting has been done in the fault zone between the granite and the volcanic rocks near the south end of the Joyita Hills. The vein material is chiefly fluorite, and the deposit was prospected for this mineral. No production is reported. Johnston[1] describes the deposit as follows:

> The fault zone contains two well-marked planes of movement. The outer or eastern one is displayed in a narrow brecciated zone running north and south and dipping to the east. This breccia zone is in rhyolite and forms the east face of the Joyita Hills in the neighborhood of the prospect. A distinct fault plane dipping to the east and exhibiting well-marked slickensides occurs 60 feet west of the brecciated zone. * * * Fluorite occurs both in the brecciated zone and on the fault plane between the granite and rhyolite.
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> Half way up the slope an adit has been driven S. 30 E. for 70 feet. For

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[1]Johnston, W. ID., Jr., Fluorspar in New Mexico: N. Mex. Sch. of Mines, State Bur. of Mines and Min. Res. Bull. 4, pp. 126-127, 1938.

20 feet from the portal the adit is in a brecciated rhyolite which includes a 7-foot band of brecciated and recemented fluorspar.

The brecciated ore appears to have been formed by the reopening of the fluorspar-filled vein with subsequent cementation by quartz and iron oxide. A considerable tonnage of such material is exposed along the brecciated zone.

The adit ends at the granite wall of the inner fault. Here slickensides are conspicuous but no ore was found.

On the crest of the hill is a north-striking vein of fluorite, calcite, and small amounts of quartz and galena which dips 40 to the east. This appears to be on the inner fault encountered at the end of the adit. The fault fissure is 8 feet wide and contains 2 feet of fluorspar on the footwall. A shaft has been sunk approximately 25 feet on the vein, just above the adit.

The brecciated ore at the mouth of the adit consists of green and white angular fluorspar fragments up to 2 inches in diameter cemented by iron oxides and quartz.

Malachite occurs at the shaft along the fault plane and for a few feet along vertical joints in the granite normal to the fault. The malachite appears chiefly in tufts of acicular crystals in quartz-lined cavities in the fluorite ore. This copper mineralization appears sparsely for several hundred feet along the fault zone in the granite.

DEWEY MINE (JENKINS PROSPECT)

The Dewey mine comprises a number of shafts on a long eastward-trending vein in the granite. The main shaft, which is near the west end of the vein, is approximately 5 miles slightly east of north from the town of San Acacia.

The vein appears as a prominent ridge extending for approximately 3,000 feet. It strikes N. 75° E. with very little variation. The dip, as observed in an arroyo near the shaft, is about 68° SE. Eastward the vein pinches gradually. At the west end, however, it pinches more abruptly to a tight barren seam about 100 feet west of the main shaft. Erosion at this place has removed the hanging wall rock and exposed the foot-wall as a bold escarpment.

The vein filling is chiefly fluorite and barite with subordinate galena and quartz. At some places fluorite is the dominant mineral and at others barite. Galena is more abundant in the western part of the vein than elsewhere and occurs as small bunches distributed in the other minerals. The vein becomes more siliceous near its extremities.

Johnstone gives an analysis of the material mined from a shallow shaft on the vein about 1,500 feet east of the main shaft. The analysis is as follows : 12.16 per cent CaF_2, 1.57 per cent $CaCO_3$, 38.06 per cent $BaSO_4$, 0.90 per cent PbS, 34.65 per cent SiO_2, and 12.52 per cent Al_2O_3 and $Fe2O_3$. The vein material at this place consists of 4 feet of barite, fluorite, chart, and a very small amount of galena.

The main shaft was in bad condition when visited and an examination of the deeper part of the vein could not be made.

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[1]Op. cit., p. 128.

It has been examined by Gordon[1] who described the mine as follows:

> A vein which is 3 to 5 feet wide cuts the gneiss nearly parallel with the strike of the limestones and associated beds. The ore (galena) occurs in bunches distributed in a gangue of quartz, barite, and fluorite, which occupies the full width of the vein. The walls are usually well defined and are covered to a thickness of one-fourth to one-half inch with clay gouge. At the Dewey mine a shaft has been sunk on the vein to a depth of 300 feet. No water was encountered. In the upper 230 feet the dip is about 65 SE.; below that it is 75 to 80 . Above the change of dip the ore mostly follows the hanging wall, but below that point it occurs principally along the foot-wall side. No shipments have been made from the mine, but about 100 tons of ore now lie on the dump. It is a low-grade galena ore carrying very little gold or silver. The well-defined character of the vein and the fact that it maintains this character to the bottom of the shaft indicate its continuation to a point considerably below the present workings.

A short vein which strikes about N. 56° E. and dips 50° SE. outcrops about three-fourths of a mile northward from the Dewey mine close to the contact with the quartzite. The vein filling is banded and is chiefly fluorite, with subordinate barite and a small amount of galena. Most of the fluorite is white and coarsely granular but the last deposition is in semi-transparent lemon-yellow cubes, some of which attain a length of three-fourths of an inch. There is much gouge along the hanging wall.

Two shafts about 300 feet apart have been sunk on this vein. The southernmost one is about 8 feet deep and exposes 2 feet of solid vein material. At the other shaft the hanging wall has caved and closed the shaft at a depth of 15 feet.

COPPER PROSPECTS

Copper mineralization occurs at the Joyita prospect as already described.

About one-fourth of a mile east of the east end of the Dewey vein and not far west of the lava-granite contact is an 8-foot shaft on an oxidized showing of copper mineralization in a vertical fissure which bears about due east. Chalcopyrite is the chief mineral. Incipient enrichment by chalcocite through bornite took place before oxidation became effective. A microscopic trace of covellite is present as an oxidation product in addition to more abundant malachite and chrysocolla.

No other ore was noted along this fissure.

POSSIBILITIES

According to Johnston,[2] who made a special study of the fluorspar deposits of New Mexico, a few tons of metallurgical lump could be mined from the Joyita fluorspar prospect in times of high fluorspar prices. The ore of the Dewey mine cannot be mined

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[1] Gordon, C H , op cit (Prof Paper 68) p 241

[2] Op cit , pp 127-128

profitably at present, but Johnston suggests that radical advances in milling procedure whereby both fluorite and galena, and perhaps barite also, could be saved might alter this situation. As Gordon[1] points out, the vein should continue to a point considerably below the present workings, and at greater depth sulphides may become more abundant.

The copper deposits offer little hope for commercial exploitation. The deposit at the main exposure shows only incipient secondary enrichment. It represents the deeper part of the secondary copper zone, so that only primary ore may be expected beneath it. The deposit is so small that little hope may be entertained for any valuable bodies of primary ore.

Lead seems to offer the best chance for commercial operation of the ore deposits of the Joyita Hills. It is present in promising quantities at the Bachelder-Everheart prospect, where the failure to work the deposit profitably seems to have been due to a great extent to metallurgical difficulties.

The contact between the Magdalena formation and the pre-Cambrian rocks underlies a considerable area west of the arroyo. The limestone lens within the Magdalena quartzite seems to have been a favorable location for ore deposition, and the unexposed portions of it offer promising prospecting ground. There may be other limestone lenses within the quartzite which are ore-bearing and some of these may crop out. Underground prospecting for such lenses would be expensive and notably uncertain.

Mineral-bearing solutions may have been able to penetrate the shale into the limestone above at some place along the transverse faults, and it is possible that ore bodies may occur there.

Copper is known to be present in this small area, and there is a chance that it occurs in the lower parts of the lead veins where it may add to the value of the ore.

HANSONBURG DISTRICT

GENERAL REMARKS

Mention of the Hansonburg district has appeared in several public reports,[2] but until recently the district appears to have been indifferently considered by all those who have had occasion to report upon it. Most of the reports refer only to the copper occurrences which are casually mentioned as "Red Beds" deposits. The lead deposits, as represented at the Hansonburg Lead mine, have been described recently by T. P. Wootton[3] in detail.

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[1]Gordon, C. H., op. cit. (Prof. Paper 68), p. 241.

[2]Jones, F. A., New Mexico mines and minerals, pp. 103-104, 1904.

Lindgren, Waldemar, et al., The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, pp. 77, 203, 1910.

Johnston, W. D., Jr., Fluorspar in New Mexico: N. Mex. Sch. of Mines, State Bur. of Mines and Min. Res. Bull. 4, pp. 123-124, 1928.

[3]Johnston, W. D., Jr., Idem.

The field work leading to the present report has disclosed that the copper deposits are not of the "Red Beds" type, but that they occur in limestone and are structurally similar and apparently genetically related to the lead deposits.

GEOGRAPHY

LOCATION

East of Senator H. O. Bursum's Hansonburg ranch and north of the exposed area of pre-Cambrian rocks which form the west front of the Sierra Oscura, the range has been broken by a number of northward-trending faults. A few miles west of this place a group of low hills of Carboniferous rocks rise above the plain of the Jornada del Muerto. These two areas constitute the Hansonburg district. The main prospects are the Hansonburg Lead (McCarthy) mine along the fault zone in the main range, visible from Bursurn's ranch, and the Hansonburg Copper mine along the fault which forms the west front of the outlying hills.

An unfortunate feature of the district is its location at the edge of the desert where no water is available for mining or milling purposes. If ore deposits warranted the expense, however, at least a small supply could be had by drilling and pumping.[1]

TOPOGRAPHY

The crest of the Sierra Oscura rises in places 3,000 feet above the plains of the Jornada del Muerto along a steep westward-facing escarpment. Where the range enters the district the cliffs are lower and begin to merge into the hills to the north. The east face of the range forms a gently dipping slope which to the north passes with minor interruptions into the Chupadera Mesa. An arm of the desert completely encircles the low hills that constitute the southwest part of the district. These hills present a low slope to the east and an abrupt, though low, series of cliffs to the west, similar to the main range although on a much smaller scale.

ACCESSIBILITY

The entire district is easily accessible under normal conditions. Passable roads which could be placed in good condition lead to all the more important prospects from Senator Bur-sum's ranch, which is 5 miles south of U. S. Highway 566 between San Antonio and Carrizozo.

GEOLOGY

Pre-Cambrian rocks, surmounted by cliffs of limestone of the Magdalena group which covers the eastern dip-slope, form

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[1]B1ack, R. F., and Powell, W. C., Preliminary report on the underground water in Socorro and Torrance counties: N. Mex. State Eng. Eighth Bien. Rept., pp. 111-126, 1928.

the steep western face of the Sierra Oscura. The pre-Cambrian rocks disappear under the sands of the Jornada del Muerto not far south of the mines in the northern part of the district. In the vicinity of the mines the fault-scarp front of the range is entirely in strata of the Magdalena group, which to the north and northwest pass under the Abo sandstone.

Figure 5 shows the general structural features of the Oscura Range in the Hansonburg district. A series of faults successively

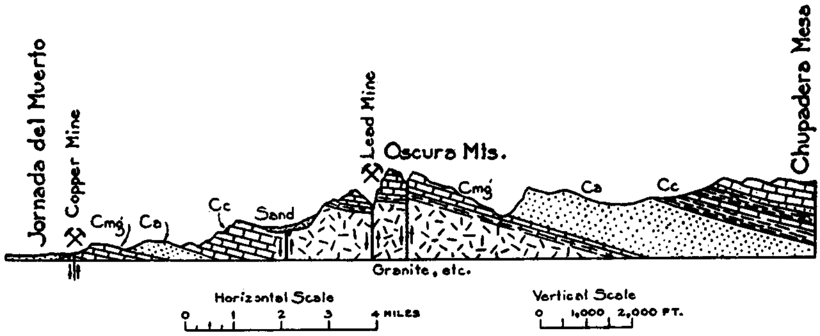

Figure 5.—Section through the Hansonburg district, Oscura Mountains, showing general structural features. Cmg, Magdalena group; Ca, Abo sandstone; Cc, Chupadera formation. Based partly on map and section by N. H. Darton (U. S. Geol. Survey Bull. 794, Pl. 17 and Fig. 77A).

step the strata down to the west, and along the trend of most of them the rocks have been deeply entrenched. The drag of the beds is clearly shown along one of the faults in the vicinity of the Hansonburg Lead mine. (See fig. 6.) The general trend of the faults is northward but the actual strike varies in gentle curves. The dip is practically vertical.

A similar fault is responsible for the western scarp-front of the outlying hills. The scarp is in Magdalena limestone upon which rest the Abo sandstone and the Chupadera formation which dip gently toward the east.

At a few places in the main range there are low outcrops which appear to be scarps of minor slips transverse to the main veins.

HISTORY AND PRODUCTION

According to Jones[1] the district first attracted attention in 1872. Prospecting was carried on intermittently, and in 1901 the Alcazar Copper Co., developed one or two properties but suspended work in the latter part of the year. Only one car of ore was shipped. Jones mentions only copper, so it is inferred that this history refers only to the copper deposits of the district.

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[1]Jones, F. A., op. cit., p. 103.

According to the present holder of the Hansonburg Copper mine, who has lived in the district for many years, the copper deposits were worked at frequent intervals from about 1895 to

Figure 6.—Portal of adit at Hansonburg Lead mine, showing drag of beds along the vein and sheeting of the footwall. Looking south. Drawn from a photograph.

1904. Work was resumed for a brief period in 1910 and has been intermittent since then. Several small lots of copper ore were shipped in 1917[1]. In all about 15 cars of copper ore have been marketed.

Schrader[2] states that a number of prospectors were at work on the lead deposits at the time of his visit, September, 1906, but no real attempt at mining seems to have been made until 1916[3] when the Western Mineral Products Co. took over the Hansonburg Lead mine and erected a 50-ton dry mill to extract the galena. This mill is still standing. Equipment consisted of a Blake crusher, rolls, trommels and a Plumb pneumatic jig.

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[1]U.S. Geol. Survey Mineral Resources, 1917, pt. 1., p. 719, 1921.
[2]Schrader, F. C., op. cit. (Prof. Paper 68), p. 203.
[3]Johnston, W. D., Jr., op. cit., p. 123.

Several cars of lead concentrates were shipped in 1917[1].

Lead and copper are the only commercially important metals of the district. Yearly assessment work is still being done at both the Hansonburg Copper mine and the Hansonburg Lead mine.

WORKINGS

There are numerous prospectors' excavations on the mineral showings throughout the district, but the only workings of appreciable size are those of the Lead mine, known also as the Rim Rock mine, and the Copper mine. The main workings of the Lead mine total approximately 1,000 feet[2], mostly drifts along the vein accompanied by crosscuts, raises and winzes, some of which connect with the surface. In addition to these workings there is a small amount of surface work and an exploratory adit above the mill which crosscuts the footwall for a minor distance and then swings parallel to the main vein for about 150 feet. A double-track gravity incline about 1,000 feet long connects the mill with the bin at the portal of the main tunnel.

At the Copper mine there are a number of shafts from 25 to 50 feet deep and numerous cuts in addition to the main workings. The gallows frame at the main shaft has caved into the collar, and the workings are inaccessible, but information which is believed to be reliable states that there are about 750 feet of workings in all. The shaft is about 60 feet deep ; a drift leads from the bottom of the shaft, and sub-levels with connecting winzes attain a vertical depth of about 300 feet. The method of exploration has been to crosscut the parallel veins of the fault zone and to follow the most promising ones.

No mill has ever been erected and shipments have necessarily been of cob bed and hand-sorted material.

CHARACTER OF THE DEPOSITS

The lead deposits occur along the faults that traverse the district and are chiefly open-space fillings. Replacement of the Magdalena limestone by silica along the fault zone in the main range is extensive, and dolomite appears as a replacing gangue mineral in the deposits in the detached hills, but there is surprisingly little replacement or impregnation of wall rock by sulphides.

The open spaces consisted of fissures, fault-breccia cavities, and small cavelike openings. The fault zone is well exposed at the Lead mine. The footwall of the fault is strongly sheeted and is brecciated along some of the planes. The breccia spaces have been filled and

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[1]U.S. Geol. Survey Mineral Resources, 1917, pt. 1, p. 719, 1921.
[2]Johnston, W. D., Jr., op. cit., p. 122.

each plane is an ore stringer. The intervening ground is slightly mineralized, forming a composite vein at one place over 40 feet wide. A little disseminated galena was found for a short distance in the hanging wall under the dragged shale bed shown in Figure 6. Residual cavities lined with minerals may still be found.

The ore along any single vein is discontinuous, and a wide well-mineralized zone may change rather abruptly to a silicified shear zone which carries only a trace of ore minerals.

The veins of the copper deposits in the outlying hills are structurally similar to those of the lead deposits. They occur at the edge of the Jornada del Muerto along the surfaces of the fault that forms the western face of the hills, and which is one of the series that blocked out the mountain range. The country rock at the outcrop is dolomitic limestone which weathers to an earthy brown color and at a distance may resemble sandstone. This is overlain by a gray crystalline limestone which has been eroded from the vicinity of the fault and which may likewise have been mineralized. The depth of the dolomitic limestone is unknown, as it was impossible to enter the workings.

The copper ore occurs as pockets or swellings along the vein, which is mineralized throughout. According to report, there is no constancy in the distribution of the pockets. The rock around each such pocket is described as "rotten." Individual pockets have been mined that were large enough to furnish a carload of ore. The character of the deposit has been affected by the chemical nature of the rock, but the location of the shoots is structurally controlled.

MINERALOGY AND DISTRIBUTION OF MINERALS

VICINITY OF THE HANSONBURG LEAD MINE

Galena is the only sulphide present in appreciable quantities in the silicified ore zone along the faults in the main range, as exemplified at the Lead mine. It occurs chiefly with fluorite but also to some extent with barite as small particles and larger bunches and as individual cubes, some of which measure as much as an inch and a half on an edge. The galena is all coarsely crystalline. Some of it is also found upon combs of quartz built upon fragments of silicified limestone. The galena has been oxidized to some extent to anglesite and cerusite. At some places the galena is replaced by a band of covellite laths which lies between galena and anglesite.

The ore is reported to run a few ounces in silver per ton. Deep etching of the galena with hydrochloric acid reveals the presence of microscopic crystals of what may be argentite. These crystals are too small for determination or for extraction for chemical tests.

Sparse microscopic particles of chalcopyrite are present in much of the galena. There are also some small particles of chalcopyrite within the anglesite associated with laths of covellite and patches of limonite. This latter occurrence is in places associated with the covellite band lying between galena and anglesite, already described, and offers a natural example of the enrichment equation : $CuSO_4+PbS=CuS+PbSO_4$. The relationship may be as follows: Oxidation of the chalcopyrite has given rise to the patches of limonite and to copper sulphate. The copper sulphate has reacted with the galena to form angle-site and secondary covellite replacing the galena. Some of the anglesite is due to direct oxidation of the galena, but the rest has been formed through the above reaction.

Copper carbonate stain is present all along the mineralized area in this part of the district. A veinlet of chalcopyrite about 2 inches wide and 4 feet long appears at one place along the outcrop of the Lead mine. Oxidation of the chalcopyrite has produced a small coating of chalcocite surrounded by banded "varnish" limonite. The vein rock adjacent to this stringer of chalcopyrite is coated with a thin amorphous film of greenish yellow cuprodescloizite (?). This mineral gives positive tests for lead, copper and vanadium.

Fluorite is by far the most abundant mineral. It occurs massive and as white, green and purple cubes. Next in abundance is barite which forms sheaves up to 4 inches long. In some of the residual cavities quartz combs appear on some of the barite plates. A common occurrence is a band of fluorite and galena upon cavity walls and breccia fragments, with the remaining space filled with barite containing some fluorite and galena.

Southward from the Lead mine and at about the same elevation are a number of surface and underground workings along some of the fault planes, where the mineralization is similar but weaker.

At the north end of the district where the faults cross the Magdalena-Abo contact, copper and lead minerals occur in about equal proportions. This is about 2 miles north of the Lead mine and at an elevation about 250 feet lower. The character of the mineralization is similar to that at the Lead mine. Galena and chalcopyrite with their oxidation products are present in a gangue which consists of much barite with somewhat less fluorite and subordinate quartz and calcite. As at the place along the outcrop of the Lead mine where chalcopyrite was relatively abundant, a coating of cuprodescloizite (?) covers much of the material. The ore is in narrow veins in silicified limestone and in the adjacent sandstone along one of the faults. Replacement is more apparent at this place than to the south.

VICINITY OF THE HANSONBURO COPPER MINE

Mineralization in the outlying hills is predominantly of copper, with one minor occurrence of galena associated with strong copper carbonate stain about a mile south of the Copper mine. The elevation of this occurrence is practically the same as at the Copper mine. The Copper mine, the chief copper prospect in the district, is about 6 ½ miles a little south of west from the Lead mine and at an elevation about 1,200 feet lower.

Lead mineralization is entirely absent. Tennantite constitutes about 95 per cent of the ore minerals. In one specimen under the microscope a few particles of what seems to be enargite were noted enclosed within tennantite. A white mineral is included within it. Microscopic particles of this white mineral may also be seen within the tennantite. It is harder than the tennantite, but the particles are too small for the application of other tests. The ore is reported to carry a few ounces of silver per ton, and this white mineral may be its source. Chalcopyrite is present within the tennantite in very minor quantities and also as isolated particles within the gangue. There is a very small quantity of secondary chalcocite and covellite. Copper carbonates and arsenates are present. A few particles of chalcopyrite appear in areas of oxidized material which seem to have been derived from the tennantite. This suggests a greater ease of oxidation for the tennantite.

An interesting feature of the local mineralogy is the absence of chalcopyrite in all specimens of the dump material which were examined, as opposed to its presence in the fresh vein material near the surface. The apparent lesser ease of oxidation of the chalcopyrite suggests that its absence in the dump material is due to initial mineral content rather than to destruction by oxidation.

Dolomite is the only gangue mineral observed. It fills the open spaces and replaces wall rock and breccia fragments of the dolomitic limestone and contains isolated particles of chalcopyrite and veinlets of tennantite. It appears to be the sole host of the sulphides, none of which could be found in rock unreplaced by gangue.

ORDER OF DEPOSITION

The distribution and character of mineralization indicate a. normal primary zoning. At the lowest elevation exposed only copper minerals are present, these consisting of tennantite with a trace of enargite (?) and a little chalcopyrite. At varying distances above this elevation lead and copper minerals in different proportions appear, and at an elevation about 1,200 feet higher the sulphides consist of galena with only a very minor quantity of chalcopyrite. The gangue associated with the tennantite is wholly dolomite; where galena is present the gangue consists of fluorite, barite, quartz and calcite.

Assuming a single source for both the lead and the copper deposits, the paragenesis of the two may be combined to give a general order of deposition for the sulphides as follows: Chalcopyrite, tennantite, chalcopyrite, galena. The trace of enargite (?) appears to be earlier than the tennantite, but its relation to the chalcopyrite is unknown.

The absence of chalcopyrite in oxidized dump material has been referred to an original absence rather than to destruction by oxidation. A logical inference is that the top dump material represents material from the deepest workings, and if this is so tennantite free from chalcopyrite constituted the ore in the lower levels. The presence of chalcopyrite at the surface earlier than tennantite therefore suggests a telescoping of the two zones.

As to the reason for the occurrence, at the Copper mine, of dolomite alone as a gangue mineral without any evidence of silica, whereas in the higher zones replacement by silica preceded all other deposition, it may be that the solutions were magnesium-bearing and that rapid change of concentration incident to passage through a dolomitic rock caused the precipitation of dolomite with the possible temporary retention of silica and the other non-metallic constituents. This is on the assumption that dolomitization of the limestone antedated mineralization, an assumption that cannot be proved since the outcrop of the dolomitic limestone is so restricted at the edge of the overlapping desert sands that it is not easy to determine the lateral extent of dolomitization.

In the higher horizons silicification of the limestone antedated the deposition of the other minerals. The solutions which followed seem to have been unable to cause any notable replacement and apparently only filled the open spaces. The first precipitation was a deposit of fluorite upon the cavity walls with contemporaneous galena and a small but variable quantity of chalcopyrite. The remaining space was almost filled with barite with continued deposition of a small quantity of galena. Thin combs of quartz were later deposited on some of the cavity surfaces.

POSSIBILITIES OF THE DISTRICT

The occurrence of the ore bodies as cavity fillings in localized areas indicates that the position of the ore shoots was determined mainly by structural features. The solutions were probably lacking in replacing power. Furthermore, silica deposited by earlier solutions partly sealed off the wall rock against replacement and possibly filled the minor cavities. Bodies of economic value may therefore be found only in the larger cavities, i. e., wide fracture zones, zones of strong brecciation, and solution cavities. It is not possible to forecast the location of such places within the limestone other than to point out the possible influence of marked distortions along the fault zone and of minor transverse faults.

Had replacement been the major process there would be a strong probability of an ore body at the contact of the limestone with the underlying pre-Cambrian granite, where rising solutions would first meet a readily replaceable rock. Under the actual conditions of cavity filling, however, there appears to be little likelihood of any great change at the contact other than more extensive silicification of the limestone.

Since replacement of the wall rock has been unimportant, deposits within the underlying pre-Cambrian rocks equal to those in the limestone are a possibility. The granite would have this advantage over the limestone; that the openings, and therefore the ore bodies, would be more regular in shape and distribution.

Zoning of deposition, such as has been described, presents an encouraging feature for further work in that part of the district where lead is prominent. Depth should disclose a greater percentage of copper minerals.

A significant feature in this part of the district is that although the full fault zone is several hundred feet wide, only a small fraction of this width has been explored. The existence of parallel or *en echelon* deposits along the fault surfaces of this zone is a very reasonable expectancy. Such deposits may be larger or smaller than those already exposed.

In a discussion of the possibilities of the copper part of the district one is limited by necessary assumptions. It has been assumed that the top dump material represents ore from the lowest workings, and on this basis chalcopyrite-free tennantite and possibly enargite and tetrahedrite would be found at lower levels. The presence of arsenic and antimony is an undesirable feature from the standpoint of smelter costs, but on the other hand appreciable silver content is not uncommon in such ores.

The possibilities of the presence of ore bodies and their location have thus far been discussed without any great regard as to their size or value. The massiveness of the fluorite and the large size of the barite and galena crystals suggest weak solutions acting over a long period of time and at such a distance from the source that the temperature had dropped to a point where rapid further change of temperature was impossible. In other words, deposition probably took place relatively near the surface. Furthermore, the relative abundance of sulphides and gangue point to a solution very weak in the metallic elements, at least in those areas now exposed. Two possibilities exist; either (a) the solutions were weak at their inception, or (b) they had already dropped part of their load. Since the source of the solutions was probably a very long way off neither possibility can be discarded, but the fact that the copper sulphides form but a very small part of the vein filling even in the lowest exposed zone suggests that the first possibility is the more likely. In either case, no deposits of unusual size or value are at all likely at depths that could be explored under present conditions. Workable deposits of moderate size and value are, however, possible, and the topography of the district favors prospecting at reasonable cost.

SAN ANDRES MOUNTAINS

GEOGRAPHY

The San Andres Mountains,[1] one of the prominent ranges in New Mexico, begin at. San Agustin Pass, northeast of Las Cruces, and extend nearly due north to Mockingbird Gap, a distance of 75 miles. The boundary between Socorro and Dona Ana counties cuts the eastern edge of the range about midway between Goodfortune Creek and Hembrillo Creek. The altitude of the adjoining plains of the Tularosa Valley is 4,000 feet, and most of the higher peaks of the range rise above 7,000 feet; Salinas Peak, the highest summit, is 9,040 feet above sea level according to the Wheeler Survey.

GEOLOGY

The range is structurally a westward-dipping monocline which is part of an anticlinal uplift faulted extensively on its east side. For many miles the eastern face is a rugged, precipitous slope of pre-Cambrian granite and other rocks, surmounted by a cliff consisting of a succession of lower Paleozoic rocks dipping to the west. The range presents to the west a long slope of Magdalena limestone, with ridges of the overlying Abo and Chupadera formations also dipping westward and passing beneath the gently rising surface of the Jornada del Muerto. There are several cross faults in addition to the main series which outlines the range, notably near the north and south ends of the range, and also many minor slips and breaks. The strata are cut by large igneous masses at the south end of the range, and at Salinas Peak a huge mass of quartz monzonite porphyry[2] is intruded in the lower limestones of the Magdalena group and extends north and especially south of the peak as a thick sill. Smaller intrusive areas that would be found by detailed work are probably present throughout the range. Two such masses occur as wide dikes near Grandview Creek

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[1]Marton, N. N., "Red Beds" and associated formations in New Mexico: U. S. Geol. Survey Bull. 794 pp. 183-193, 1928.

[2]Idem. Elsewhere (p. 192) Darton refers to this rock as microgranite.

and are possibly associated with the ore deposits in that vicinity.

Granite is the chief rock of the pre-Cambrian, but schist is very prominent locally and is more abundant than in the pre-Cambrian in other places in Socorro County. Darton[1] describes the distribution as follows:

> Massive coarse-grained granite is most abundant but schist was observed in Cottonwood, Deadman, Sulphur, Membrillo, and San Andres Canyons. In Lostman Canyon the rock is diorite containing much hornblende. Granite appears in Goodfortune and Membrillo Canyons, near Rhodes Canyon, and from Lava Gap northward.

The talus in Grandview Canyon contains fragments of hornblende diorite which appear to have been derived from the ridge between Grandview and Hembrillo Canyon. The full Paleozoic sequence is represented in the sedimentary rocks which overlie the pre-Cambrian.

ORE DEPOSITS

Figure 7 shows the location of the principal prospects in that part of the San Andres Mountains which lies in Socorro County. A lead-copper prospect, perhaps as important as those described, has been reported north of Salinas Peak, but this was not visited. Practically all the deposits are on the eastern slope of the range within or close to the pre-Cambrian rocks. To the writer's knowledge no deposits have been reported on the western slope except the Salinas Peak prospect which is near the crest. This does not signify any influence of the pre-Cambrian rocks. The pre-Cambrian has been merely brought to view by the faulting that outlined the range, and it is along this faulting and its sympathetic fracturing that the ore bodies have been formed. The minor transverse faults are subordinate features of the main displacement. Being subordinate they do not extend for any great distances, and therefore any mineralization along them would also be restricted to the vicinity of the main breaks and the pre-Cambrian rocks.

The deposits are fissure veins chiefly along faults of small displacement. Some of the mineralization in the Mockingbird Gap district occurs along the major fault that forms the east front of the range at that place. The bismuth deposits of Grandview Canyon occur at the contact of pre-Cambrian schist and granite, and the copper deposit in Sulphur Canyon appears to be a cavity filling.

The ore minerals are galena, sphalerite, pyrite, chalcopyrite, bornite, chalcocite, covellite, native bismuth, bismuthinite, bismutite, scheelite, malachite, azurite, chrysocolla, cuprite and native copper. The gangue minerals are hematite, limonite, quartz, calcite, barite, fluorite and chlorite.

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[1]Idem

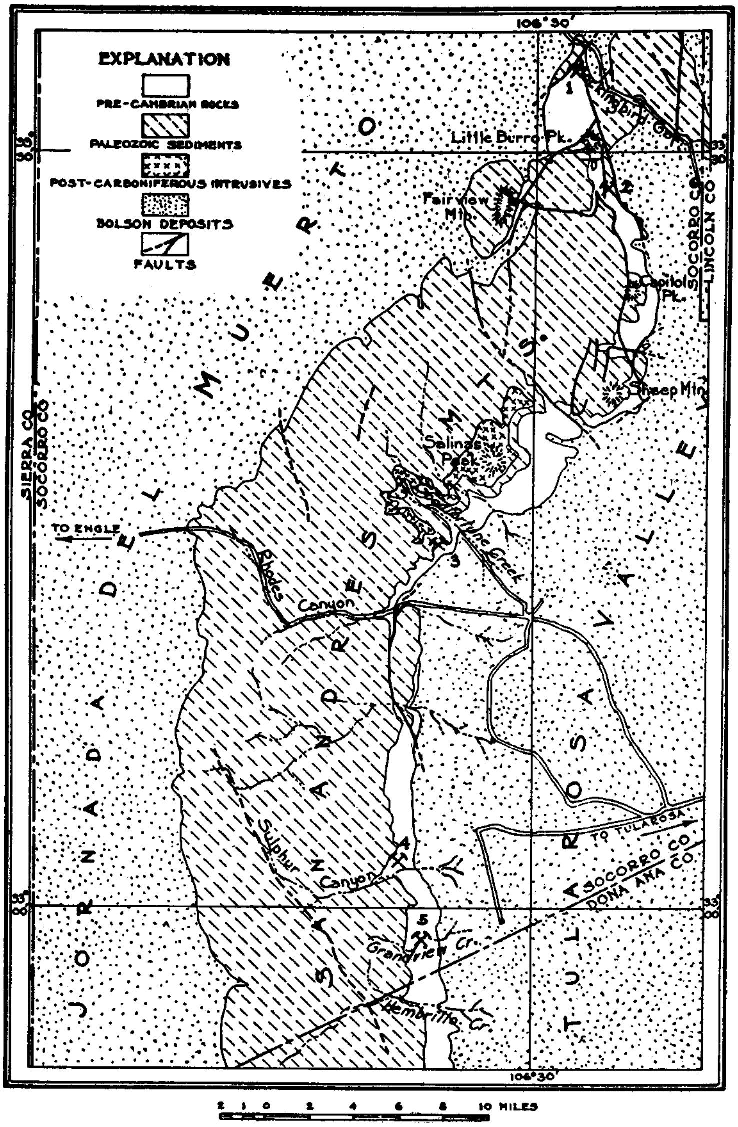

Figure 7.—Geologic map of part of the San Andres Mountains, showing location of the principal prospects. Based on reconnaissance geologic map of the San Andres Mountains, New Mexico, by N. H. Dart,on (U. S. Geol. Survey Bull. 794, Pl. 40). 1, Independence group; 2, Mockingbird Gap mine; 3, Valle Vista prospect; 4, Sulphur Canyon prospect; 5, Grandview district.

The deposits probably owe their origin to the post-Carboniferous intrusive rocks as represented by the laccolith at Salinas Peak and the dikes in the vicinity of Grandview Canyon. The only prospects which are not near or in direct association with an exposed intrusive rock are those at Mockingbird Gap. However, the type of mineralization at the Independence group of claims in this district is that which is deposited at a considerable distance from the source, so that lack of a visible association is not strange.

POSSIBILITIES

Opportunity for observation is so limited that an unreserved statement cannot be made concerning the possibilities of this area. Only a relatively small amount of work has been done on most of the prospects, and hence it would be unwise to do more than present the facts and to state the general impression that the area conveys.

Commercial deposits possibly may be found if prospecting is rationally carried on, and if favorable prospects are fully investigated. In view of the structural relationships and distribution of the deposits that have already been found, prospecting in areas of faulting in the vicinity of the post-Carboniferous intrusive rocks would offer the best chances of finding deposits of commercial size, and effort should be concentrated on a full investigation of the most favorable exposures with temporary neglect of the less favorable ones.

The location of the region with respect to the railroad should be kept in mind. Transportation by wagon or truck for at least 25 miles over unimproved roads is necessary in all cases, and for a few of the prospects this must be preceded by a few miles of burro transportation. The smaller deposits could be worked with profit only if there were larger deposits to bear the main burden of high transportation costs.

HISTORY AND PRODUCTION

The earliest record of mining encountered by the writer is an assay report on copper ore from Grandview Canyon dated June 30, 1896, although the earliest work probably antedated this by many years. The copper deposits of the San Andres Mountains were described by Herrick[1] as early as 1898. These deposits, from Herrick's description, seem to be of the type represented by the Valle Vista vein at Goodfortune Creek. From the description which Jones[2] gave in 1904 of the prospects in the region of Mockingbird Gap, it appears that some prospects in that district had been worked for a number of years prior to that time. Jones specifically mentions the

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[1]Herrick, C. L., The occurrence of copper and lead in the San Andreas and Caballo Mountains: The American Geologist, vol. 22, pp. 286-291, Nov. 1898.

[2]Jones, F. A., New Mexico mines and mineral; p. 107, 1904.

Mockingbird Gap mine, and also a galena-sphalerite prospect on the west side of the divide and south of the main road going through the gap, which is probably the Independence prospect visited by the writer.

The United States Geological Survey, in the Mineral Resources of the United States for 1906, stated that bismuth was known in southeastern New Mexico. This probably referred to the prospect of George E. Stone in Grandview Canyon in the San Andres Mountains. Quoting from the same publication for 1908:

George E. Stone, of Engle, New Mexico, reports having mined bismuth ore from claims on the east side of the San Andreas Mountains 4 miles north of the Dona Ana County line. The ore is made up of carbonates colored with copper and accompanied by some scheelite.

In 1911 this publication reports as follows:

So far as was made known to the United States Geological Survey the only bismuth-bearing ore produced in the United States during 1911 was one lot from * * * Colorado, which carried 6 to 8 per cent of bismuth but was sold for its gold and silver content, and a smaller lot of richer ore mined by George E. Stone from a claim about 35 miles southwest of Tularosa, New Mexico.

Small lots of museum specimens have been produced front this bismuth claim in more recent years and sold to schools and dealers in mineral specimens.

GOODFORTUNE CREEK

LOCATION AND OWNERSHIP

The Valle Vista prospect lies on the east slope of the range about half a mile south of the mouth of Goodfortune Creek. It is about 45 miles from Tularosa, N. Mex. The road from Tularosa for all except the last 7 miles follows State Highway 52 to Engle. The camp is at the foot of the slope and a rather steep trail continues from the camp to the mine about a mile distant. The prospect is owned and operated in partnership by George Babbers, Tom Babbers and Ed. Henderson of Alamogordo, N. Mex.

PRODUCTION

The prospect was worked in the early days but was abandoned when the ore pinched out in the back. There is no statistical record of the early production, but it could not have been more than a few tens of tons. No smelter shipments had been made in the course of the present operation at the time of the writer's visit in September, 1929, but 7 tons of hand-sorted ore was reported to be awaiting shipment at Alamogordo, and there was about 10 tons of sacked ore at the mine. About 25 to 30 tons of high-grade chalcocite ore and a smaller quantity of lower grade oxidized ore was exposed in the workings.

The owners state that a specimen of the massive chalcocite ore assayed 46.9 per cent of copper, 21.5 oz. of silver per ton, and a trace of gold. Two laboratory runs at the El Paso plant of the American Smelting & Refining Co. on average ore are said to have given the following returns: 24.5 per cent of copper and 5 oz. silzer per ton, and 26.5 per cent of copper and 3 oz. of silver per ton, respectively. There is no reason to doubt the genuineness of these figures.

GEOLOGY AND WORKINGS

The workings are at the contact of pre-Cambrian granite with the overlying Paleozoic sediments, the basal member of which is a bed 1 to 2 ½ feet thick of hematitic Cambrian quartzite. The early work was all above the granite on the impression, as noted by Herrick', that the ore did not extend into the granite, and the vein was abandoned when the ore pinched out in the back. The present workers have excavated the floor of the old tunnel, which is about 75 feet long, and were mining in the granite about 8 feet below the contact when the deposit was visited. The ore was still 24 inches wide at this depth. Judging from the size of the workings fully as much ore has been extracted from below the contact as from above it. It is difficult to imagine how this ore was missed by the early miners.

The vein is a minor practically vertical transverse fault which strikes about N. 50° W. The throw is about 8 feet, but since the latest movement, as inferred from the wide grooves on the slickensided surfaces, was nearly horizontal, the net displacement was much more than that, perhaps about 40 feet. Near the pre-Cambrian-Paleozoic contact the fault zone is composed of a number of parallel fault fissures, the strongest of which presents a brecciated zone 4 to 10 feet wide. The ore in this part of the vein consists of fillings half an inch to more than a foot in width in the series of parallel fractures which make up the fault zone. Some of the more massive and less oxidized ore perfectly preserves the slickensided fault surfaces. The ore shows no strain.

The ore is chiefly secondary chalcocite with visible residuals of primary chalcopyrite. There is a small amount of secondary bornite. The chalcocite in places is frozen to one-fourth to one-half an inch of quartz along one of the walls. It is the massive steely variety and contains veinlets of malachite and patches of earthy hematite which mark the former presence of the primary minerals. Pyrite can be seen under the microscope as untouched cubes in the chalcocite, and hematites pseudo-morphs after pyrite are also visible in many places. Quartz crystals in patches and as individuals are also embedded in the chalcocite.

Oxidation has been intense, and some of the ore consists

[1]Herrick, C. L., op. cit., p. 286.

entirely of masses of crystalline malachite, hematite, goethite, jarosite and quartz. Large nodules of jarosite are common. Hematite stain penetrates everywhere, and oxidation and enrichment are probably responsible for some of the hematite in the basal Cambrian quartzite.

The vein may be traced to the top of the range, approximately 535 feet higher than the tunnel level and about 1,515 feet above the surrounding plain. In the limestone, which extends from the early clastic sediments to the summit of the range, the fault appears as a silicified brecciated zone about 10 feet wide. The southern end of the Salinas Peak sill lies within this limestone and is displaced by the vein. At one place the vein swells out mushroom-like on the under side of a bedding plane for about 15 feet on each side of the main channel. A very small quantity of chalcopyrite was found about 125 feet below the summit as a replacement of the siliceous limestone. It is associated with a trace of galena and secondary bornite and chalcocite, the gangue minerals being barite and fluorite.

SECONDARY ENRICHMENT

The Valle Vista deposit was originally a fissure filling accompanied by some replacement, in which the primary sulphides were chalcopyrite and very subordinate pyrite. The presence of untouched pyrite within the chalcocite indicates the former presence of abundant more readily replaceable sulphide. The present character is that of an oxidized secondarily enriched deposit in which the masses of chalcocite represent practically complete replacement of similar masses of chalcopyrite.

The enriching copper was not derived from any part of the vein now existing but must have come from some part that has been removed by erosion. The original fault face of the range was at least half a mile east of the present slope. The vein probably did not extend as far eastward as the outermost fault, but there would still have been sufficient vein area present to have furnished more than enough copper for the enrichment. The secondary solutions probably moved along the vein down the contact between the granite and sedimentary rocks and formed the rich ore bodies at that horizon.

POSSIBILITIES

The Valle Vista vein is similar to many that occur along the east front of the range. The Blackenden prospect on the north side of Goodfortune Canyon, about a mile from the mouth, and the Mockingbird Gap mine are similar deposits. The fact that ore has been found at the Valle Vista vein within the granite suggests that neighboring prospects may have ore in that rock.

In this district it is especially advisable to "follow the ore" until evidence of mineralization ceases, and this is particularly true at the granite-quartzite contact. Unfortunately a number of veins of the kind described were abandoned, seemingly on a preconceived notion, without following this rule.

The secondary ore bodies very probably were derived from masses of at least equal size, and there seems to be no reason why unenriched or partially enriched primary ore bodies may not be found. Since chalcopyrite is the chief primary mineral such bodies would probably be valuable. It would indeed be fortuitous if the best ore shoot of each vein had been exposed by erosion.

MOCKINGBIRD GAP DISTRICT

MOCKINGBIRD GAP MINE

The Mockingbird Gap vein is similar to the Valle Vista vein except that oxidation has preceded erosion to such an extent that practically no sulphides are exposed. The location of the mine is designated as "2" in Fig. 7. It lies at the intersection of the granite-quartzite contact with a fault which trends N. 10°-25° W. and dips 60°-75° NE. The main tunnel, which is about 150 feet long, is driven along the fault near the quartzite horizon. The granite-quartzite contact is exposed in the foot-wall of the fault at the portal. The hanging wall is hematite-hearing sandstone. At the face of the tunnel and for some distance back the footwall is brecciated granite, and the well-defined hanging wall consists of shale, sandstone, and limestone.

About 100 feet from the portal of the tunnel a winze 50 feet deep follows the hanging wall. Other workings consist of a shaft approximately 50 feet deep in the footwall a short distance back of the portal and a shallow pit about 100 feet north of this shaft.

The ore minerals include a very small quantity of chalcocite in which oxidation is well advanced, malachite, azurite, chrysocolla, cuprite and a trace of native copper. No primary sulphides are present. The gangue consists of abundant fluorite and limonite, some hematite, and a little calcite. Copper carbonates are present in subordinate joints in the hematitic quartzite and sandstone above the granite in the footwall just west of the main tunnel.

The mine has been idle for many years. All easily available ore seems to have been mined.

INDEPENDENCE GROUP

The Independence group of claims is at the north end of Mockingbird Gap. They are at the north end of the fault zone which brings up the granite hills visible to the west on passing through the gap. This fault zone continues southward past the Mockingbird Gap mine to Capitol Peak. The dumps of the different workings and the two cabins that constitute the camp can be seen clearly from the road. The group includes 6 patented claims held by E. H. Thompson of San Marcial, N. Mex.

The main workings are on the Independence claim about a quarter of a mile up an arroyo which bears south from the camp. These workings consist of a 2-compartment timbered shaft 114 feet deep with short crosscuts and drifts at 50-foot levels. The workings total 175 feet. The ore occurs in a silicified and brecciated zone in limestone, which strikes about due south. Granite outcrops a few hundred feet to the east of this zone.

Another silicified outcrop lies several hundred feet east of the Independence shaft. It also strikes about due south. The dip is 65°-70° E. The outcrop is prominent and forms a decided fault scarp in places with granite in the footwall and silicified limestone in the hanging wall. The vein has been explored by shafts and open cuts for a distance of approximately three-fourths of a mile south of the camp. The vein becomes gradually less brecciated to the south and finally changes to a sheeted zone.

Both sulphide and oxidized ores occur at the Independence group. The sulphide ore consists of galena and sphalerite in a gangue of coarse calcite and subordinate barite and quartz. Galena occurs in places in the outcrops, and the sphalerite, which is of the clear yellow variety, appears close to the surface.

The oxidized ore contains lead and zinc carbonates, some anglesite, and a small quantity of residual galena and sphalerite. The gangue includes barite, calcite, quartz, manganese oxides, breccia fragments of sandstone, and a characteristic limonite.

Southward along the vein of the main workings the sulphides diminish in quantity until the vein filling consists only of coarse calcite and a little barite.

According to the owner, two carloads of ore were shipped from the Independence shaft to Joplin, Mo., about 1920. The assays were approximately as follows: 2 per cent lead, 10 per cent zinc, 10 oz. silver per ton, and a trace of gold. A shipment of 5 tons of sorted ore from the eastern vein is said to have netted $456 of which $95 was for silver. This ore contained no zinc.

The character of the ore and gangue in these deposits indicates deposition by weak solutions at a considerable distance from the source. Prospecting at greater depth may be justified.

SALINAS PEAK

A favorable copper-lead prospect has been reported in the vicinity of Salinas Peak, but it was not found practicable to visit it. The following description has been extracted from conversations with various people interested in the prospect. It is believed that this description presents a fairly reliable statement of actual conditions.

The claims are about 3 ½ miles slightly east of south of the Thurgood ranch[1] at the narrowest part of the intrusive body north of Salinas Peak. They were formerly known as the Crawford prospect. The vein is along a fault contact between the intrusive and sedimentary rocks. The fault strikes about N. 10° E. and dips eastward. The hanging wall is intrusive rock and the footwall is Magdalena limestone. The vein is several feet wide and carries galena, chalcopyrite, malachite and azurite. A small amount of fluorite and limonite constitutes the gangue. The fault zone is from 5 to 20 feet wide and is traceable for about 3,000 feet.

There are about 1,000 feet of workings, mostly tunnels. An assay report from the American Smelting & Refining Co. at El Paso, Tex., dated September 23, 1929, gives the following figures: 21.6 per cent of lead, 2.04 per cent of copper, 0.8 oz of silver per ton, and a trace of gold. The ore was valued at $20 a ton.

SULPHUR CANYON

An abandoned mine which is said to have produced a fair quantity of high-grade copper ore lies in pre-Cambrian schist about one mile above the mouth of Sulphur Canyon. The shaft of this mine was investigated to a depth of 50 feet but could not be penetrated farther because of the rotten timbers.

The copper minerals, which are chrysocolla and malachite, are associated with a mass of chlorite. No primary ore minerals were observed. The chlorite has a sharp contact with the enclosing sericite schist and appears to be a lens within it. This lens is about 10 feet thick at the shaft, but chlorite and copper minerals disappear entirely not more than a hundred feet distant. Considerable hematite occurs locally near the contact, and some of the schist is deeply colored by it.

The chlorite is chiefly a mass of thin books in heterogenous orientation, but some of it is slightly schistose. The oxidized copper minerals are later than this semi-schistosity and are also later than the hematite. The deposit seems to have been entirely worked out.

The Sulphur Canyon deposit is isolated and there is no obvious reason for its existence. It may be pre-Cambrian but is probably of later age.

The following explanation of origin may be applicable to this deposit: When a fault of moderate displacement crosses

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[1]Darton, N. H., op. cit., plate 40.

a schistose rock the tendency of the schist is to bend instead of to break. This results in a series of short en echelon fractures which individually strike at an angle to the direction of the fault but collectively lie within the prolongation of that direction. Each of these fractures would normally be a short, thin, lens-like opening unconnected with any of the others. These openings are potential receptacles for ore, and the deposit in Sulphur Canyon may be of this type. If so, it must be associated with one of the minor cross faults, since the major faults have a displacement of at least hundreds of feet and would have sheared through the schist. If examination of the limestone to the west and the granite to the east should disclose a fault which, if prolonged, would intersect the ore body, the relationship would be fairly certain, and there would be a good chance of finding other ore bodies in the schist along the strike of the fault similar to the deposit that has already been worked.

GRANDVIEW CANYON

LOCATION

Grandview Canyon is a minor canyon which lies about midway between Sulphur and Hembrillo Canyons about 3 miles north of the Dona Ana County line. It is about 4 miles west from the Ritch ranch which is 35 miles from Tularosa, N. Mex.

GEOLOGY

The ore deposits of the district lie within the pre-Cambrian area. Granite and schist are the most prominent rocks. An upturned ledge of quartzite outcrops near the upper limit of the pre-Cambrian area in "greenstone" which appears to be altered igneous rock. It is a heavy dense grayish-green rock. Microscopic examination discloses some free quartz in very small grains. Alteration to chlorite and locally to calcite is very far advanced and has destroyed most of the original character of the minerals, but there remains a semblance of the original igneous texture. A notable amount of kaolinization has occurred. There are in places a few shadowy outlines that seem to be twinned feldspars, and elsewhere a few hazy pleochroic areas that may be augite residuals.

A wide dike which strikes northwestward cuts the pre-Cambrian rock on the ridge between Grandview and Sulphur Canyons. It appears to extend through the overlying sediments to the top of the range. The rock is a gabbro containing over 50 per cent labradorite in minute crystals encroaching upon augite and olivine, which are present in nearly equal proportions. A trace of biotite is present and also a moderate quantity of opaque minerals. A similar dike is reported about 2 miles farther south. The sheared "greenstone" may be related to the gabbro but is more probably pre-Cambrian.

ORE DEPOSITS

The district is well covered by mining claims, all of which were located by George E. Stone of Tularosa, N. Mex. The claims have been located upon bismuth, tungsten and copper deposits. The most prominent of these deposits is on the Pioneer claim, where bismuth and tungsten are the chief metals. A vein of chalcopyrite has been prospected on the Greenback claim. The Junior Pioneer claim, about a mile southeast of the Pioneer and an equal distance northeast of the Greenback, is also said to contain bismuth ore and scheelite, and copper is reported on the claims just west.

All these deposits lie within the area bounded by the two westward-striking dikes that have been described. The northern of the two dikes is about a quarter of a mile north of the Pioneer claim.

POSSIBILITIES

The statements that have been made with respect to the possibilities of the San Andres region in general apply with particular emphasis to the area around Grandview Creek. A relatively small amount of work has been done on each of the pros-

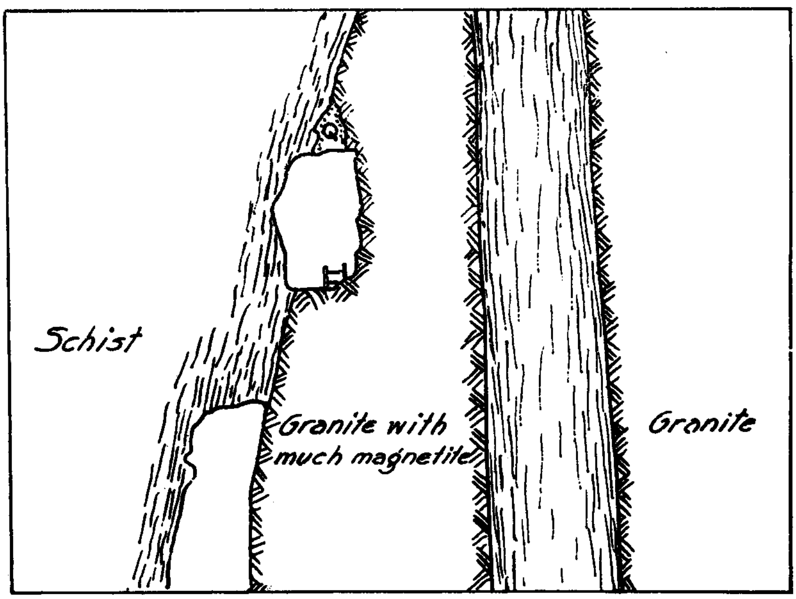

Figure 8.—Sketch of portal at Stone's bismuth prospect, Grandview Canyon, San Andres Mountains, showing part of quartz lens (Q) in back of upper tunnel and relation of workings to granite-schist contact.

pects mentioned above, and one may only guess at the reasons that led to this scattered prospecting instead of a concentrated effort to prove the value of any single prospect. Mineralization, though generally weak, is rather widespread along all the fractures, but development is not sufficiently extensive to permit much generalization as to the distribution of the ore.

PIONEER CLAIM

The Pioneer claim is a short distance up a northward-bearing branch canyon about a mile and a half from the mouth of Grandview Canyon. The portal of the tunnel can be seen from the plain below. It is about a quarter of a mile south of the gabbro dike described.

The ore occurs at the contact of a very fine grained granite which contains abundant magnetite and which is separated from the parent granite mass by a 4 ½-foot dikelike body of rock somewhat similar to the intruded schist. (See Fig. 8.) Lenses of quartz 6 to 10 feet in diameter and 2 to 5 feet thick lie at the contact of the granite with the schist. The bismuth minerals occur as pockets of different sizes within these quartz shells. A small detached body of quartz and scheelite was found on this contact only a few feet distant from the bismuth ore, but it contained no noticeable bismuth minerals. The schist adjacent to the ore lenses is said to carry about one per cent of bismuth.

The ore minerals are bismuthinite, native bismuth and bismutite. Native bismuth is rare. There is also present a brownish-gray amorphous mineral which, from its reaction to various tests, seems to be bismuth carbonate admixed or absorbed in clay. Strong copper carbonate stain is present, and pyrite is locally abundant. Microscopically, chalcopyrite is present with the bismuthinite where pyrite is also present. A very minor quantity of chalcocite replaces chalcopyrite and bismuthinite. Small masses of jarosite are common.

Two ore lenses have been mined. A reported shipment of 1,500 pounds of ore in 1918 assayed 70.2 per cent bismuth and some gold and silver. Very little ore can be seen in place. Much of the ore has been sold for specimens. The workings consist of three adit levels 15 feet apart and total approximately 250 feet in length.

GREENBACK CLAIM

The Greenback claim is about 1 ½ miles southwest of the Pioneer claim. The claim is located along a northward-bearing shear zone in the "greenstone" near the top of the pre-Cambrian. The "greenstone" is schistose adjacent to the shear planes and at these places carries pods and veinlets of chalcopyrite and calcite in isolated shoots and bunches.

The main workings consist of approximately 400 feet of drifts and crosscuts from a single adit. (See Fig. 9.) The drifts follow a number of the shear planes which were exposed underground by crosscuts. A little ore shows at the face.

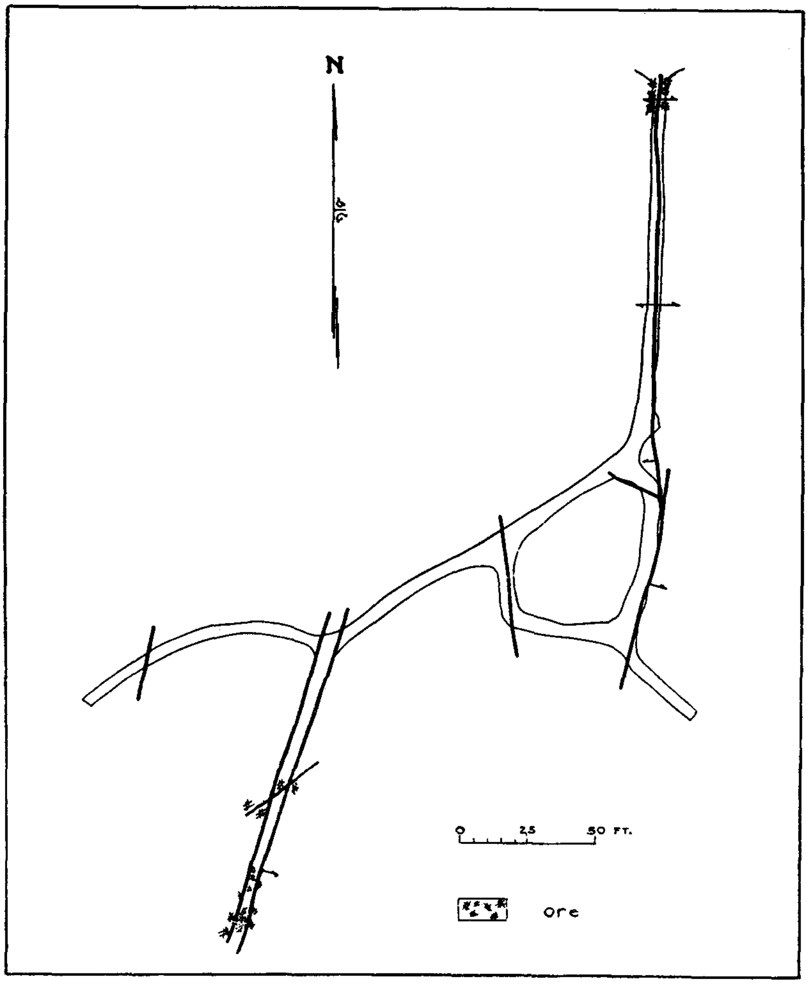

Figure 9.—Sketch plan of Greenback tunnel. Grandview Canyon, San Andres Mountains.

A few hundred feet northward across the canyon there is a shaft 100 feet deep on the vein which at this place carries strong malachite stain. A small pit a few feet west of this shaft discloses a fault contact between the sheared "green-stone" and quartzite. Weak mineralization may be traced for some distance.

SIERRA LADRONES

LOCATION

Ladron Peak, at about the center of the Sierra Ladrones, is in the northwest corner of T. 2 N., R. 2 W. The triangular base of the range is approximately 10 miles on a side with the western side bearing about N. 20° W. The southern tip lies just north of the Rio Salado.

The range is accessible only during certain parts of the year, when the Rio Salado and its numerous tributary arroyos are dry or nearly so, and always with difficulty. It is sometimes possible to reach the southern foothills at Cerro Colorado by automobile from Magdalena, about 25 miles southwest, or the bed of the Rio Salado may be followed from San Acacia, about 15 miles southeast. The topography is so rugged, however, that the best mode of entry to the interior of the area is by horse from San Acacia.

GEOLOGY

The Sierra Ladrones is essentially a large mass of pre-Cambrian granite faced on the west slope by Mississippian and Pennsylvanian strata and rising over 3,000 feet above the Quaternary and Tertiary plains which, except for a narrow strip of Pennsylvanian limestone at the northern end, completely surround the range. Ladron Peak, in the pre-Cambrian area, is the highest point on the range with an elevation of 9,214 feet (Wheeler Survey).

The pre-Cambrian rock is mainly a light-colored, fine-grained granite which contains much hornblende schist in dike-like areas. The granite that forms Cerro Colorado is, as the name of the hill suggests, a deeper red than the rest of the area and is gneissoid and coarse-grained. These rocks are intruded by rhyolite and andesite dikes. Basalt dikes are noticeable in the bolson deposits to the east.

The pre-Cambrian rocks are covered by westward-dipping Carboniferous strata which are mainly Pennsylvanian limestones. At the southern end of the mountains a band of Mississippian (Lake Valley) limestone intervenes between the pre-Cambrian and the Pennsylvanian. It extends northward about 3 miles before thinning outs and represents the northernmost exposure of Mississippian rocks in the state. Near Cerro Colorado, where the Lake Valley limestone was examined by the writer, 1 ½ feet of conglomerate occurs as the basal member. (See Fig. 10.) Above this lies 2 feet of red sandstone and then 6 to 8 inches of green shale. The shale is covered by an arenaceous limestone which merges up ward into a gray crystalline limestone which appears to be composed of minute

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[1]Darton, N. H., "Red Beds" and associated formations in New Mexico: U. S. Geol. Survey Bull. 794, pp. 17, 131, Plate 26, 1928.

fragments. Nothing resembling the "Silver Pipe" bed of the Magdalena district was observed.

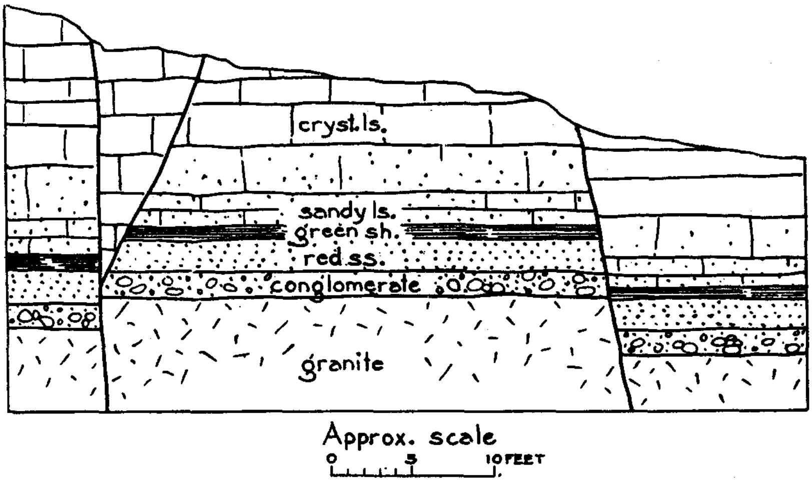

Figure 10.—Sketch section of lower part of Lake Valley limestone on west side of limestone tongue east of Cerro Colorado, Sierra La-drones. Looking S. 30 E., parallel to dip of beds.

A tongue of limestone penetrates the pre-Cambrian area for about a mile at the southern end, forming a hook which embraces Cerro Colorado. It is broken by numerous closely-spaced dip faults and appears to represent a minor southward plunging syncline imposed upon the general monoclinal attitude of the strata.

The Pennsylvanian strata extend southward to the Rio Salado where they form canyon walls, and northward beyond the granite where they connect with the large area of Permian and Triassic strata to the west.

The pre-Cambrian and sedimentary rocks are separated from the Santa Fe formation and bolson deposits to the east by well-marked faults.

ORE DEPOSITS

Very little evidence of important mineralization has been found in the Sierra Ladrones. Because of the decidedly rugged nature of the region, prospecting has not been carried on here as vigorously as elsewhere.

Copper has been found at two places, and unsuccessful attempts have been made to exploit each of the deposits. They are about 4 miles apart, and if they should continue along their strike would form a single zone trending westward. At one of these places, the Juan Torres prospect, fluorite is prominent, and a small amount of fluorspar is the only shipment made from the prospect. The copper mineralization, which the writer believes to be the more important economically, seems to have been ignored. Galena has been reported along the contact between the granite and the limestone, but the writer was unable to find any indication of it.

JUAN TORRES PROSPECT

The Juan Torres prospect is in Sec. 18, T. 2 N., R. 2 W., at the head of Mule Spring Arroyo south of Ladron Peak.

Figure 11 is a sketch of the north walls of a small trench

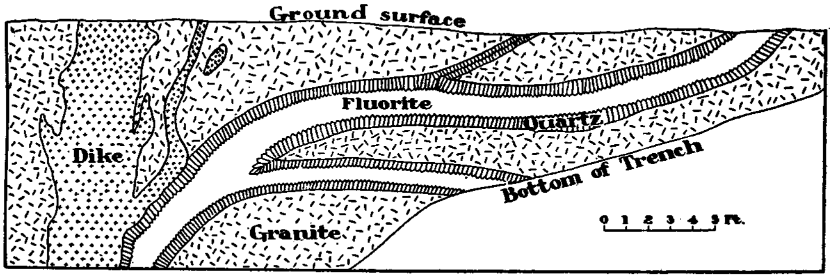

Figure 11.—Sketch of face of vein, Juan Torres prospect in the Sierra Ladrones. (After W. D. Johnston, Jr.)

which is the only working on the property. Johnston[1] describes the occurrence as follows:

> The pre-Cambrian granite is cut by a 5-foot dike of fine-grained andesite. East of the dike and extending beyond the limits of the trench are two small horizontal veins which merge at the andesite and granite contact. The veins attain a maximum width of 2 ½ to 3 feet. Lining the veins and in contact with the granite walls is a band of quartz occurring in crystals up to 6 inches in length and showing well developed pyramid-terminated prisms. The fluorspar fills the space between the quartz on the walls of the vein.

The veins do not appear to extend far from the dike. Specularite and chalcocite occur with the quartz, and veinlets of specularite penetrate the fluorite. The chalcocite found in place occurs as small blebs and veinlets, but larger masses of oxidized material were observed on the dump. At the time of the writer's visit the trench was badly caved, but enough of the vein matter was exposed to permit the collection of a number of specimens which were carefully examined to determine, if possible, any significance of the specularite.

Chalcocite is the most important sulphide. It is the orthorhombic variety and shows a well-developed natural parting.

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[1]Johnston, W. D., Fluorspar in New Mexico: N. Mex. Sch. of Mines, State Bur. of Mines and Min. Res. Bull. 4, pp. 124-125, 1928.

Twinning can be seen under the microscope. A small quantity of covellite replaces chalcocite. Oxidation of the chalcocite still in place has been slight. In a single specimen a very few microscopic residuals of bornite were found within chalcocite and at one place, associated with the bornite, a single speck of chalcopyrite. A minute microscopic fragment of specularite was also found enclosed in chalcocite, and although a number of small areas of specularite and magnetite (?) were seen, this was the only occurrence of ferric oxide that could be found in contact with a sulphide.

In one specimen examined under the microscope fluorite was seen in the same field with chalcocite and specularite.

From the not very abundant information that the writer was able to gather, the following order of deposition appears probable : Quartz, fluorite, specularite, bornite, chalcocite, covellite and carbonates. The bornite is probably a replacement of some other mineral which has been completely consumed, presumably chalcopyrite.

RULE PROSPECT

The Rule prospect is in T. 2 N., R. 2 W., in the Sevilleta (La Joya) Grant at a place that would correspond approximately to Sec. 14. The fault contact between the pre-Cambrian and the Tertiary-Quaternary deposits to the eastward is irregular, and in the vicinity of the Rule prospect a small area of loosely cemented arkose of the Santa Fe formation extends northwestward into the granite. A basaltic dike separates the granite and the arkose on the northeast side of this area and shows slickensided contacts. The dike rock and the arkose are widely permeated by copper carbonates and a very minor amount of silicate in fractures which extend in many directions. Copper carbonates form part of the cementing material in some of the arkose. Mineralization has penetrated slightly into the granite, and both the mineralized granite and the dike rock contain, in addition to the oxidized minerals, disseminated microscopic particles of pyrite, chalcocite and covellite.

Numerous shallow shafts have been dug, and an unsuccessful attempt has been made to work the deposit. There are a small jaw crusher, a pump, two concrete tanks, and a pile of iron scrap about half a mile from the workings. It is reported that the milling process consisted of leaching and precipitation of the copper on iron scrap.

POSSIBILITIES

So far as the writer knows, only two metalliferous deposits have been found in the entire Sierra Ladrones district. At each of these copper is the chief metal, and neither constitutes an obviously workable deposit. The amount of work done at the two places is negligible and the areas open to observation are very small, and for these reasons no concrete statement as to the general possibilities of the district can safely be made.

Specifically, the relations observed at the Juan Torres prospect hazily suggest prospecting at higher elevations in the range. The presence of the ferric oxides as apparently early vein minerals which have been only slightly attacked, if at all, by sulphide-carrying solutions, suggests that the present horizon is near the bottom of the sulphide zone and that there will be a gradual impoverishment of the sulphides with depth, that is, nearer the source of the solutions.' Conversely, more abundant sulphides may be expected farther from the source. The Juan Torres prospect is at a relatively low elevation in the deeply-eroded bre-Cambrian rocks, and it is therefore possible that prospecting at somewhat higher elevations may disclose workable sulphide ore bodies. The deposit has been opened to such a slight extent that it would be advisable to prospect the occurrence more fully before definitely concluding that little sulphide ore lies below the present working.

At the Rule prospect it is probable that the presence of the sulphides was not known, since they occur in microscopic particles. Possibly all assays were accepted as indicating copper carbonate. Some cheap treatment designed to extract the sulphides as well as the carbonates might prove successful. It appears unlikely that richer ore may be found at this place.

SAN LORENZO DISTRICT

The San Lorenzo district, which derives its name from the San Lorenzo Arroyo, contains two small copper prospects in the southwest corner of the Sevilleta (La Joya) Grant, about 7 miles west of the town of San Acacia. The prospects are at an elevation of about 5,725 feet in the volcanic area which constitutes the northward extension of the belt of volcanic rocks of the Lemitar and Socorro Mountains. A passable road leads from San Acacia directly to the prospects. Reports[2] were current in the press during 1909 of the discovery of these ores.

A wide slickensided and brecciated fault zone which strikes about due north separates the andesite and basalt which are exposed here. Oxidized copper ore appears in this zone at two places about a quarter of a mile apart. The ore minerals include chrysocolla, cuprite, native copper and malachite. The gangue is amethystine and white quartz and calcite.

Workings consist of a few shallow shafts, pits and cuts. These few workings seem to have been sufficient for the mining of all the

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[1]Butler, B. S., and Burbank, W. S., Relation of electrode potentials of some elements to formation of hypogene mineral deposits; Am. Inst. Min. and Met. Eng. Tech. Pub. 166, Feb. 1929.

[2]Gordon, C. H., op. cit. (Prof. Paper 63), p. 241.

ore as only a few faint showings can now be seen. It is reported that a few sacks of ore were shipped. Remnants of small piles of ore on the dumps tend to substantiate this report.

LEMITAR MOUNTAINS

LOCATION

The Lemitar Mountains form a northward-trending range about 7 miles long between the Socorro Mountains to the south and the Sierra Ladrones to the north. The crest of the range lies approximately 4 miles west of the town of Polvadera, which is 12 miles north of Socorro.

GEOLOGY

Darton[1] describes the Lemitar Mountains as follows:

> The Socorro and Lemitar Mountains are parts of a westward-dipping succession of Tertiary igneous rocks on a platform of limestone of the Magdalena group underlain by pre-Cambrian rocks. * * * Granite is a prominent feature for 6 miles along the east slope of the Lemitar Mountains.
>
> To the east of these mountains are long sand and gravel covered slopes extending to the Rio Grande and in part underlain by tilted sandstone of the Santa Fe formation, which are well exposed near the north end of the Lemitar Mountains. To the west * * * lies a thick body of Tertiary igneous rocks, which extend to the wide valley separating these ranges from the Magdalena Mountains.

The pre-Cambrian rock includes some schist associated with the granite and enclosed in it. Granite gneiss occurs at a number of places. Basic dikes and younger pegmatite dikes are prominent features. Epidote is common in some of the pegmatites. In the southern part of the mountains south of Corkscrew Canyon, the sedimentary series is very similar to that of the Magdalena district. The basal member is a thin bed of quartzite. Overlying this is about 90 feet of crystalline limestone which contains a central member approximately 10 to 12 feet thick of very dense light gray limestone which resembles the "Silver Pipe" bed. Although no fossils were found, the very great similarity of these beds and their sequence to the Kelly limestone of the Magdalena district strongly suggests that they represent the Lake Valley limestone. Overlying these beds is a series of shales, quartzites, and limestones highly suggestive of the Sandia formation. These rocks are faulted by a number of transverse faults which are marked by prominent quartz outcrops. Along Corkscrew Canyon a northward-bearing fault is exposed which separates the Magdalena formation from the volcanic rocks to the west of them.

ORE DEPOSITS

The ore occurs as a fissure filling in small scattered pockets

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[1]Darton. N. H., "Red Beds" and associated formations in New Mexico: U. S. Geol. Survey Bull. 794, p. 85, 1928.

along the contacts of the granite with the schist and the basic dikes in the foothills of the northeast slope of Polvadera Mountain, about 3 ½ miles west of the town of Polvadera. One occurrence is associated with a narrow pegmatite dike within a larger dike of basic rock. The ore consists chiefly of galena with subordinate chalcopyrite or sphalerite locally. The associated gangue minerals are quartz, fluorite and barite. The barite occurs as curved, pale pink to salmon-red plates. The ore is very siliceous in places.

Numerous small ore showings can be found for a considerable distance along the mountain front. The rising mineral-bearing solutions, seeking the easiest channels of egress, seem to have followed for the most part channelways along the contact between the granite and the basic dikes. At some places mineralization appears along some other contact.

The deposits have been prospected by surface pits only. Picked samples are said to have given assays fairly high in silver. The report on a 20-pound sample of average outcrop vein matter, which was sent to the smelter of the American Smelting & Refining Co., at El Paso, gives the following assays: Gold, trace; silver, 0.6 oz. per ton; lead, 7.2 per cent; total lime, 36.1 per cent; available lime, 22.6 per cent. The smelter offered a credit of $1.81 a ton because of the high available lime, at that time equivalent to about one per cent lead in the ore. Fluorite is common as a gangue mineral. It should continue with depth, and hence a lime credit could reasonably be counted upon which would raise the value of some of the ore.

In addition to the above prospects, a few shallow shafts have been sunk on the south slope of the Lemitar Mountains on traces of galena along the contact between the granite and the limestone. South of Corkscrew Canyon and near the fire-clay pits a little oxidized zinc ore was extracted from a shear zone in pre-Cambrian schist. The surrounding rock is locally impregnated with copper-carbonate stain.

SAN MATEO MOUNTAINS

LOCATION AND GEOLOGY

The San Mateo Mountains cover a roughly elliptical area of over 800 square miles southwest of the Magdalena Mountains. The major axis of the ellipse, which trends southwest, is about 45 miles long and extends about 8 miles into Sierra County. The mountains consist of an accumulation of volcanic material, chiefly flows of rhyolite and their associated tuffs. Underlying flows of andesite are exposed at the southern end of the range. The only mapped area of sedimentary rocks is a patch of Magdalena limestone at the edge of the rhyolite along Nogal Creek.

In contrast to the Magdalena Mountains, the main part of the range is remarkably free from dikes. At the southern end of the range, however, where the lower flows are exposed, dikes are abundant. They range in character from rhyolite to basalt and other basic dikes, and they strike and dip in different directions. Along Alamosa Creek a surprising view can be obtained of basaltic bodies containing xenoliths of rhyolite and trapped by overlying flows of rhyolite.

ORE DEPOSITS

Gold is the chief metal in the ore deposits of the San Mateo Mountains. In the Rosedale district, the most important producer in this area, the ore mined was valuable only for its gold content. In the San Jose district the ores contain silver in addition to the gold. A lead deposit occurs south of the old fort of Ojo Caliente in the southern part of the range, but possibly this ore deposition was related to the mineralization of the Fairview-Chloride district, a short distance to the south.

ROSEDALE DISTRICT

ROSEDALE VEIN

Location.—The abandoned town of Rosedale lies about a mile within the edge of the hills on the northeastern slope of the San Mateo Mountains. It is about 25 miles slightly west of south from Magdalena and about 30 miles a little north of west from San Marcial. The roads from either of these towns are passable without any great difficulty.

History and Production.—Gold was discovered in the San Mateo Mountains in 1882.[1] A rush to the district followed the discovery, but development work was handicapped by frequent incursions of the Apache Indians under Geronimo.

The Rosedale mine[2] has the reputed distinction of having paid dividends for about 15 years simply from ore extracted during development. The Rosedale Mining Co. was formed about 1886. The property was acquired by the E. H. Martin Co. in 1898 and was operated continuously until 1911, when the mine was shut down. Practically no stoping was done during this period. It is said that the shutdown was due to dissension among the Eastern backers rather than to any difficulty at the mine. The ore was treated by amalgamation and cyanidation in a 10-stamp mill. According to Gordon[3] about 450 tons of ore was produced monthly.

The property was sold in 1913 and was worked by the new owners until 1916 when a fire which destroyed the mill and spread to the mine caused a second shut-down which has

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[1]Gordon, C. H., op, cit. (Prof. Paper 68), ppń 259-260.

[2]The writer is indebted to J. H. Robb of San Marcial, N. Mex., for much information concerning the Rosedale mine.

[3]Gordon, C. H., op. cit. (Prof. Paper 68), p. 260.

continued to the present time. Mining was confined mainly to stoping during this second period of operation. The total production of gold probably amounted to several hundred thousand dollars. It was reported in 1930 that the mine had again been sold.

Workings.—Figure 12 shows the entire workings of the Rosedale mine except the minor crosscuts. The shaft is 732 feet deep, and approximately one mile of workings extend from it. The caved part of the workings is not shown.

Geology.—It was impossible to enter the shaft, and hence most of the following statements are based on observations made at the surface and in the adit.

The ore occurs in a well-marked brecciated and sheared zone in rhyolite porphyry. The strike is N. 20° W. and the dip is 75°-90° SW. The vein is in a brecciated band along the upper side of the shear zone and is 3 to 5 feet wide. The shear zone extends for 25 to 30 feet into a footwall of white rhyolite porphyry. The hanging wall is pale reddish-brown rhyolite porphyry, and breccia fragments of this rock are abundant in the vein.

The brecciated and sheared rhyolite has been partly cemented by banded bluish-white quartz. This has also been fractured, and the entire mass has been recemented with glassy vein quartz. The walls have been silicified, and the outcrop stands out clearly.

The vein carries free-milling gold. According to Gordon' numerous assays are said to have given an average value of $10 a ton in gold. No silver is present. There is a small quantity of limonite throughout, and much manganese dioxide occurs near the portal of the adit in stringers and as films on the fracture surfaces. The manganese, which is said to be associated with the higher grades of ore,[2] becomes decidedly less as distance is attained in the adit. Sulphides appear below water level which is at a depth of 726 feet[3]. Some of the quartz in the oxidized ore above water level contains cavities formerly occupied by other minerals.

Figure 12 shows the two ore shoots that have been located. These shoots apparently join with depth. The distribution of the manganese in the adit corresponds with the length of the shoot on that level.

Structural Relations.—An interesting feature at the Rosedale tunnel is the fact that the vein becomes tighter as it becomes steeper, and accompanying this change the amount of manganese present diminishes. The change in the amount of manganese may be referred in part to the depth of oxidation,

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[1]Idem.

[2]Idem, and local information

[3]Idem.

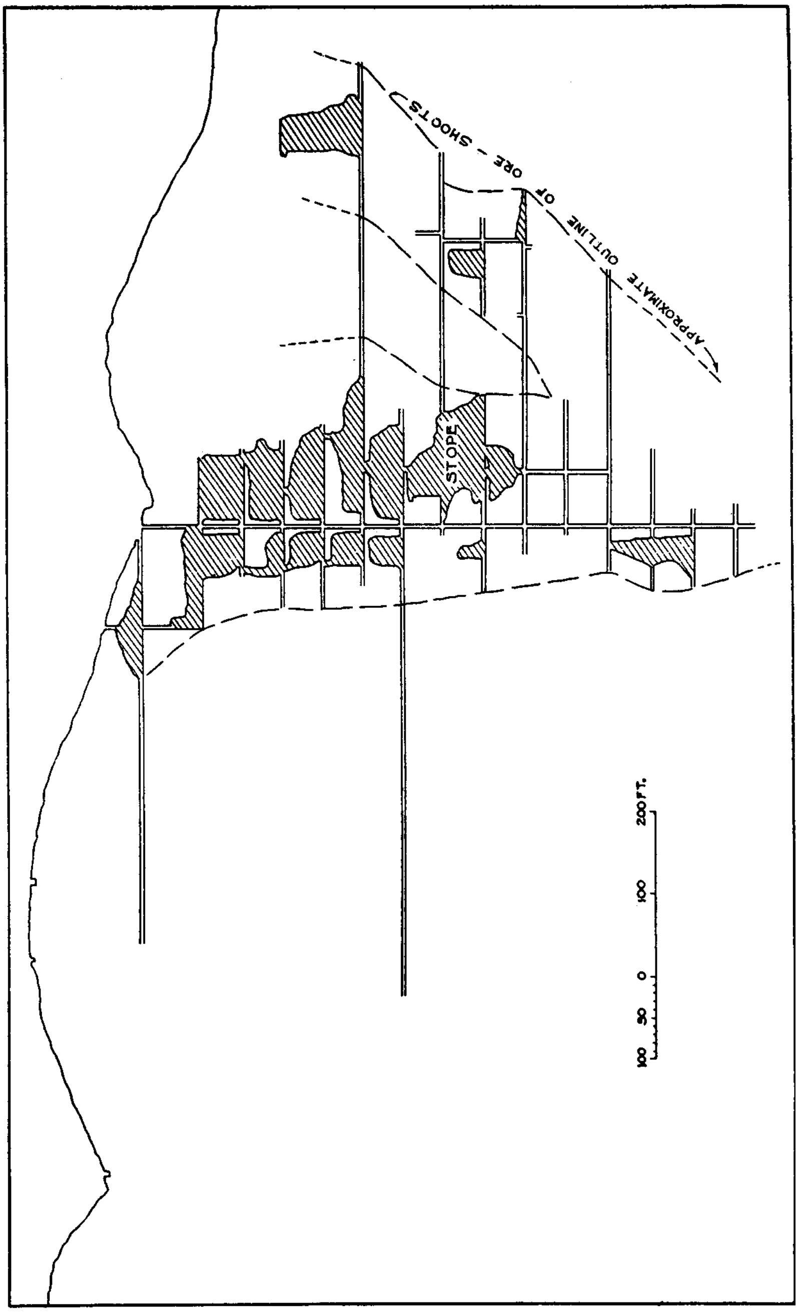

Figure 12.—Rosedale mine in the San Mateo Mountains, vertical projection. Looking N. 70 E.

but it is significant that this change accompanies a marked change in both the physical character and attitude of the vein. It is probable that this circumstance indicates that the location of the ore shoot was controlled by the warp that is indicated by the change in dip along the fault surface. Similar warps may have caused the localization of other shoots.

The vein is traceable for some distance to the north, and 7 claims are located upon it. To the south, however, it appears only in the arroyos and the lower ridges. The rhyolite in the few higher ridges shows more evidence of flowage than that in the vein walls and may be a different flow. Vegetation and talus make it difficult to find any possible contact without considerable difficulty, but it appears that the vein has been covered by a later flow. If this is true it is an important feature, since there may be a number of workable veins in the district which do not outcrop. The suggestion is supported by an occurrence in Alamosa Canyon where irregular intrusive masses of basalt in rhyolite are capped by other rhyolite flows, which, though older than the basalt itself, are later than the formation of the fractures up which the basalt came and thus prevented it from reaching the surface.

Robb Prospect.—The Robb prospect is on the claim that adjoins the Rosedale mine on the south. The vein at this place is 10 feet wide. Mr. Robb reports ore valued at $12 a ton at the bottom of a 20-foot winze. Fine-grained volcanic breccia which carries considerable manganese is visible in the bottom of this winze. The rhyolite at this prospect and especially in the ridges between it and Rosedale shows some flowage features and contains feldspar phenocrysts in addition to the quartz.

LANE PROSPECT

The Lane prospect is about 2 miles north of Rosedale in Whitecap Canyon not far east of Whitecap Spring. The vein is well defined and strikes northwest. It is very similar in many respects to the Rosedale vein. The ore is said to be somewhat richer than at Rosedale.

NEW GOLDEN BELL VEIN

The New Golden Bell prospect is in sec. 12, T. 6 S., R. 6 W., on a vein similar to the Rosedale vein and parallel to it. The prospect includes three claims which were surveyed for patent in March, 1927. The latest development work was in the summer of 1929. The vein carries silver and gold in small quantities. No shipments have been made.

SAN JOSE DISTRICT

GENERAL FEATURES

The San Jose district is near the crest of the rugged southeastern part of the San Mateo Mountains. The main part of the district lies in T. 8 and 9 S., R. 5 W. It is 20 miles south of the Rosedale district, 50 miles by road from Hot Springs, and 63

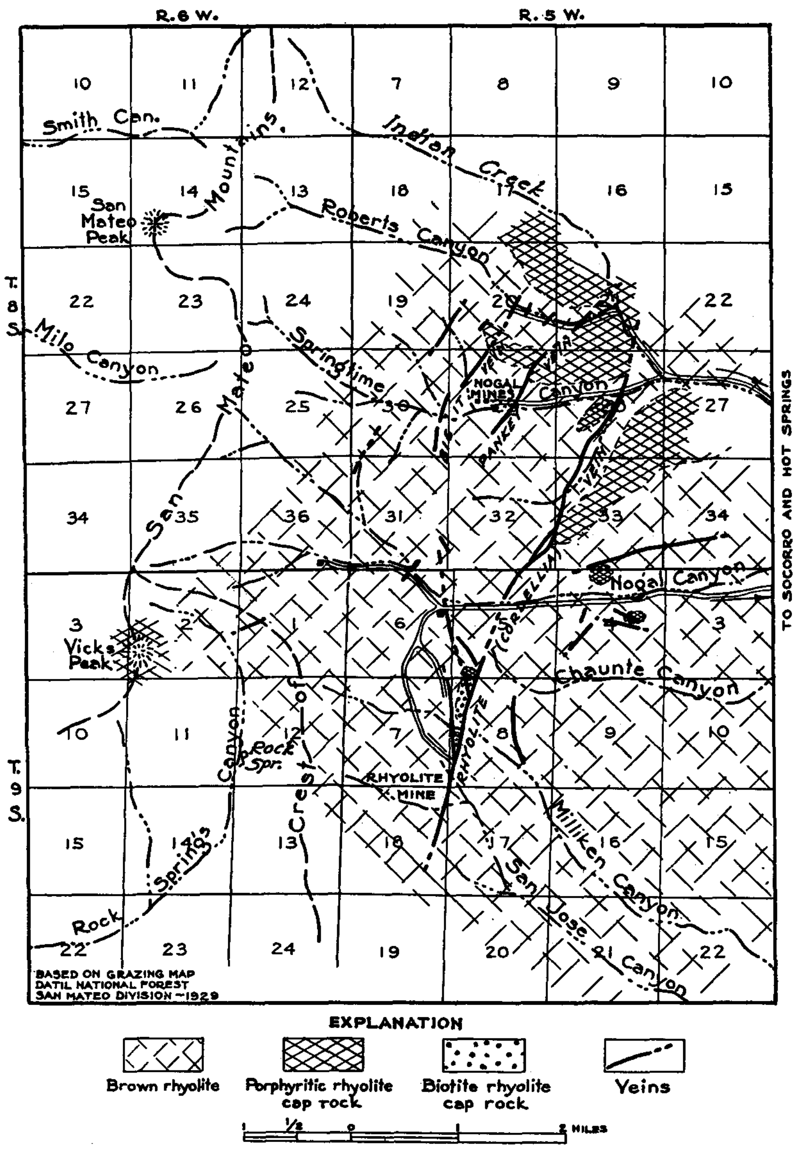

Figure 13. —Geologic sketch map of the San Jose mining district in the San Mateo Mountains.

miles by road from Socorro. An excellent 12-mile road has been constructed from Springtime Canyon to the main highway between Socorro and Hot Springs, and passable roads reach to nearly all other parts of the district.

Many canyons traverse the area, and their steep walls are in sharp contrast to the rounded tops of many of the hills that bound them. The average slope is about 30°. The slopes are well covered with timber suitable for mining and construction, and a sawmill is maintained in Nogal Canyon. Springs and wells can furnish water for domestic use, but a supply sufficient for mining and milling purposes may be difficult to obtain.

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 Tom Hellyer discovered high-grade gold-silver ore in the outcrop of the Pankey vein in. Springtime Canyon. The news of this discovery brought many prospectors to the district, and all open ground was soon located. The Pan-key property was acquired by the Nogal Mines, Inc., and an excellent modern camp was built.

Three cars of ore, amounting to 160 tons, were shipped from the outcrop of the Pankey vein in March, 1932, and constitute the entire production of the district. The average gross value of this ore was $8.64 per ton. Very little development work has been done on any of the veins. The most extensive workings are those of the Rhyolite mine, which include about 225 feet of drifts and crosscuts and 50 feet of shafts and winzes. At the time of the writer's visit, in April, 1932, two adits were being driven on the Pankey vein near the bottom and on opposite sides of Springtime Canyon, but these had progressed only a short distance.

THE ROCKS

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.

Rhyolite Porphyry.—The most prominent rock in the district is a purplish-brown rhyolite porphyry which underlies the eastern slope of the San Mateo Mountains in this vicinity. In Springtime Canyon and at the extreme eastern edge of the volcanic area this rock is prominently flow-banded in streaks and bands of brown and gray and contains small white tabular feldspar phenocrysts and a few nests and streaks of quartz in a felsitic groundmass. The phenocrysts make up about 5 to 10 per cent of the rock, which is very brittle and breaks readily into small slabby pieces. The physical character of this rock is responsible for the steep canyon walls.

As determined by microscopic examination the feldspar phenocrysts consist of microperthite and infrequent grains of oligoclase and range in shape from idiomorphic laths to corroded and broken grains and shapeless intergrowths with quartz and glass. Most of the perthite resembles, in both orientation and shape of the albite blebs, the film and string types discussed by Ailing,[1] both of which types students of perthites believe to be due to exsolution and therefore pyrogenetic. Some of the phenocrysts seem to more nearly resemble the patch type in which the albite patches are believed due to later replacement.

The quartz of this rock occurs chiefly as thin flow-bands alternating with much broader bands of glass and microcrystalline intergrowths of glass and quartz. An occasional corroded phenocryst and isolated nests blending into the glassy ground-mass are also present. Flakes of dark brown biotite and crystals of zircon are present, but they are rare. The glassy bands are extremely dirty. They contain considerable magnetite and opaque dust drawn out in fluxional lines. All bands wrap around the phenocrysts, which are unoriented.

Sharp ribs, which resemble silicified vein outcrops, crop out here and there through the flow rock. The rock of these ribs is a brown, aphanitic siliceous-appearing material containing only a few minute feldspar phenocrysts and is megascopically entirely devoid of the flow features so prominent in the surrounding rock. A thin section of the rock shows a few small orthoclase phenocrysts and a larger fragment of the surrounding perthitic rhyolite in a matrix composed of a nearly cryptocrystalline intergrowth of quartz, glass and subordinate feldspar. Some of the larger quartz areas show penetrating feldspar laths in micropoikilitic intergrowth. Incipient fluxion appears around some of the phenocrysts.

At some places, particularly south of Springtime Canyon, the rhyolite porphyry is generally massive and externally similar to the ribs of massive rock in Springtime Canyon. Flowage features occur only locally and are inconspicuous. The phenocrysts are small, as in the flow-banded rock, and consist of quartz and orthoclase, microperthite or sanidine.

The upper part of the rhyolite porphyry has been strongly bleached and discolored and ranges from white to deep red in color. The discolored part forms a broad band which is prominent in many parts of the district and underlies most of the southern part. The thickness of the discolored zone ranges from about 50 to 200 feet. Discoloration extends most deeply along faults and strong fracture zones, and this feature is present on a small scale in the discolored rock itself, the strongest discoloration appearing along joints and flow-lines. Microscopic examination of the discolored rock east of the Pankey vein discloses that the discoloration is due to limonitization of

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[1]Ailing, H. L., Perthites: Amer. Mineralogist, vol. 17, pp. 3-65, 1932.

the opaque dust of the groundmass. The feldspar phenocrysts are remarkably fresh and only lightly stained with limonite here and there. Kaolin is present but not prominent. Except that the dust of the groundmass is limonite, the discolored rock hardly differs from the fresh rhyolite porphyry.

The base of the rhyolite porphyry series does not crop out within the district. A thickness of about 1,100 feet is exposed in Springtime Canyon, and the full thickness may be considerably greater.

Breccia and Tuff.—Volcanic breccia and tuff, about 25 feet thick where exposed in Springtime Canyon, overlie the rhyolite porphyry series, and these rocks are in turn generally overlain by a coarse porphyritic rhyolite which caps the rounded hills of the district. In Springtime Canyon a layer of flow rhyolite lies between the tuff and the porphyritic rhyolite. The breccia and tuff are discolored like the underlying rhyolite porphyry and at some places contain cavities up to several inches across lined with irregularly oriented quartz prisms.

Porphyritic Rhyolite.—The porphyritic rhyolite that caps the breccia and tuff ranges in color from dove gray to grayish-blue and lavender and is rather soft as compared to the brittle, hard flow-banded rhyolite porphyry. It contains about 20 per cent of medium and coarse-grained idiomorphic feldspar phenocrysts in a somewhat sugary groundmass. Phenocrysts and groundmass are nearly identical in color. Black grains of magnetite are common. This rock also is bleached and discolored in places, particularly in the vicinity of strong faults. Microscopic examination shows perthite phenocrysts in a microcrystalline matrix consisting of 65 per cent of feldspar and 35 per cent of quartz. Numerous scattered grains of magnetite and needles of ilmenite (?) and a number of apatite prisms, some enclosed within magnetite, are present. A single flake of bleached biotite was noted.

The perthite of the rock is of several varieties. Most of the feldspar phenocrysts have a complete rim of albite which sends invading patches into a core that seems to be pyrogenetic perthite. (See Fig. 14.) These albite rims represent a late albitization of the original feldspar. Some of the perthite is Alling's "penetrating" type[1] showing adjacent grains of perthite mutually penetrating each other. This type he believes to be deuteric in origin, formed during late magmatic stages by introduction of albite from without the crystal.

A few hundred feet west of the Pankey vein a dike of rock

[1]Idem.

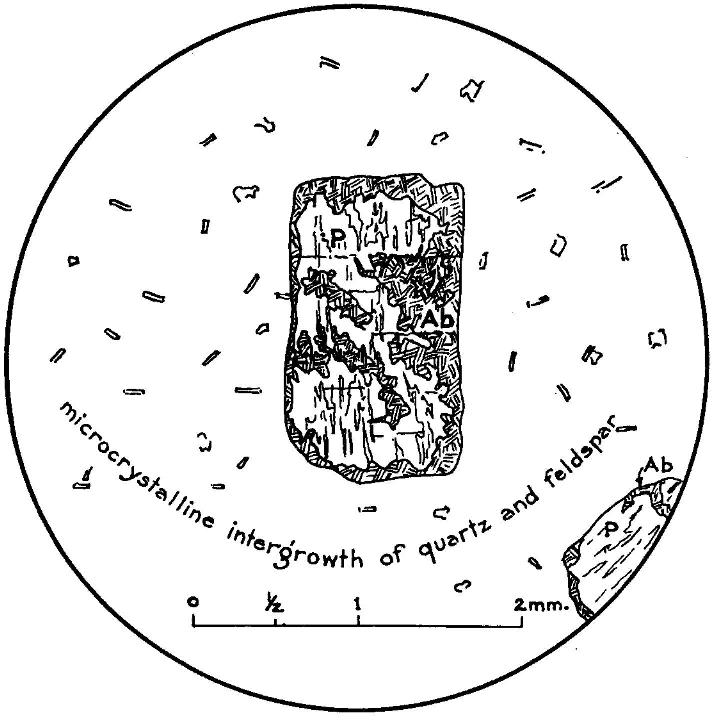


Figure 14.—Camera-lucida drawing from thin section of porphyritic rhyolite cap-rock, showing albite (Ab) replacing perthite (P).

similar to but finer grained than the porphyritic rhyolite cap-rock, cuts the brown rhyolite porphyry and extends toward the crest of the ridge. An attempt to trace this dike to the porphyritic rhyolite was unsuccessful because of the talus and slide rock. Microscopically the dike rock differs from the porphyritic rhyolite only in being finer grained and in the surprising characteristic that all the phenocrysts are albite (An_6) instead of some variety of perthite. The rock may be properly called a keratophyre, though it may be an end phase of the albitization shown in the flow rock.

The porphyritic rhyolite is several hundred feet thick in places, but just north of Milliken Park it wedges out completely between the brown rhyolite porphyry and an overlying biotite rhyolite.

Spherulitic Biotite Rhyolite.—The biotite rhyolite lies above the thinning-out wedge of porphyritic rhyolite north of Milliken Park, but south of this place it rests directly on the breccia and tuff. The lower few feet is highly spherulitic, grading upward into seemingly non-spherulitic pseudo-bedded porphyry. This rock contains about 40 per cent or more of highly corroded orthoclase phenocrysts, a little oligoclase and several per cent of dark brown biotite in a brown glassy groundmass that shows remarkably delicate fluxional banding following all the intricacies of the phenocryst outlines. Zircon and less abundant apatite are accessory minerals. Parts of the groundmass show the black crosses of closely-packed minute spherulites under crossed nicols. Elsewhere the groundmass has a cryptocrystalline development which shows readily visible stellate, needle-like, spherulitic aggregates. Quartz nests are prominent, and in many cases they cut across the fluxion lines of the ground-mass. All the visible quartz is apparently secondary. The fluxion lines follow the outlines of some quartz nests, but these seem to be quartz pseudomorphs of corroded feldspar grains. Partial silicification of some of the feldspar grains is clearly shown.

Rhyolite Dikes.—In Nogal Canyon are several dikes of white porcelaneous rhyolite. One of the most prominent is on the north side of the canyon opposite the old sawmill camp. It is intensely silicified but here and there retains some of the flowage features.

STRUCTURAL FEATURES

The tuffaceous rocks and the porphyritic cap-rock of the district dip in general northeastward at about 8°. The attitude of the underlying rhyolite porphyry series is somewhat different, judging from the attitude of the highly developed, unwarped flow-banding of a great part of the series. This differs in widely separated parts of the district but is rather constant in the vicinity of Springtime Canyon with a dip of about 15° southeastward.

The district contains several prominent faults and numerous minor breaks. Most of these are mineralized, and they are shown as veins on the geologic sketch map of the district, figure 13. They differ considerably in strike, and with the exception of the Rhyolite (Cordellia) vein are rather steep. The throw ranges from almost nothing to several hundred feet. The discoloration and bleaching so prominent in the rhyolite porphyry are present to some extent in the overlying rocks as well, particularly in the vicinity of faults, and extend most deeply along faults and strong fracture zones, indicating that this alteration was later than some of the faulting. At many places the discolored upper part of the rhyolite porphyry lies against fresh rock along a fault surface. This suggests faulting after the discoloration, but at these same places there is also indubitable post-fault discoloration. Perhaps there was only one period of faulting and one period of alteration with the permeable breccia and tuff above the rhyolite porphyry permitting very ready penetration by the altering solutions, in which case there would be a tendency for alteration to be confined to a particular horizon. Nevertheless, at a few places, it is difficult to avoid the conclusion that altered rock has actually been faulted against fresh rock. Since discoloration and bleaching of the rock is largely confined to the upper part of the rhyolite porphyry, the distribution of this altered porphyry aids in locating faults.

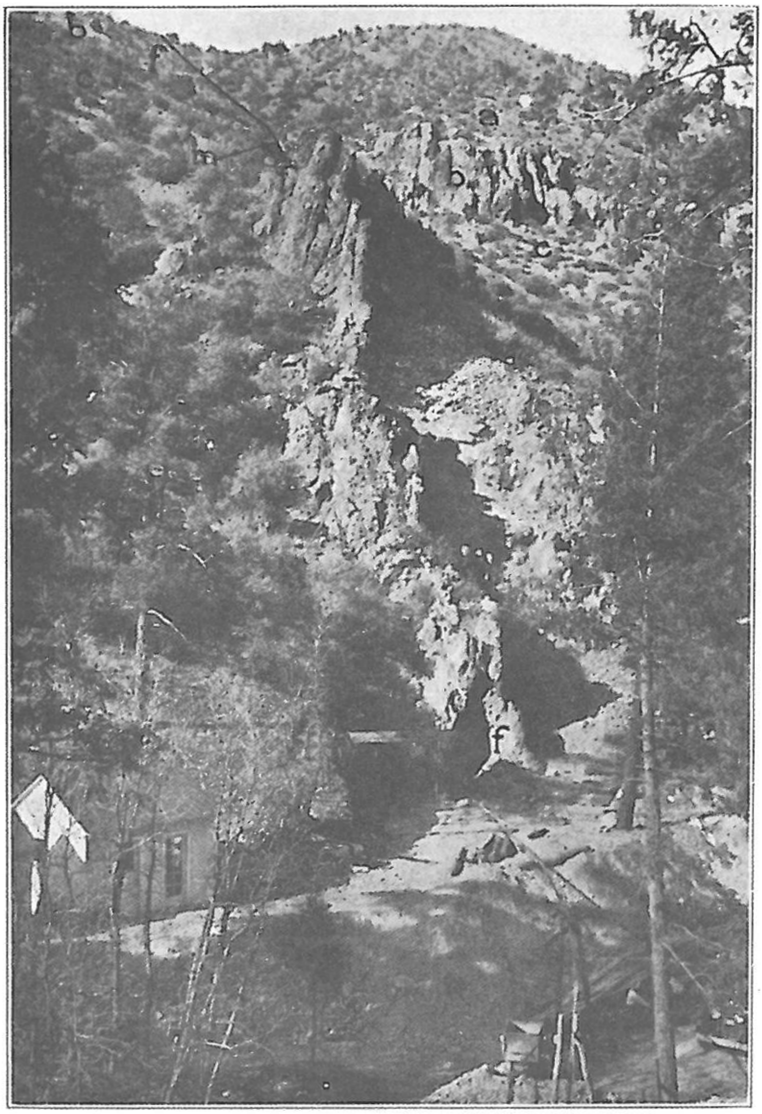
The Rhyolite fault is the most prominent of the district. Its average strike is about N. 20° E. and the average dip about 70° NW. It can be traced in a zone up to 100 feet wide from south of the Rhyolite mine northeastward across Milliken Park, Nogal Canyon and Springtime Canyon to Indian Creek, a distance of about 5 miles. The fault zone is marked by a line of discontinuous staggered outcrops, and at several places the cap-rock of the district can be seen in the hanging wall dropped down against the underlying rock. At the top of the ridge on the north side of Nogal Canyon the cap-rock lies in the footwall of the fault, counterfeiting a reverse fault. The explanation of this feature may lie in a strong horizontal component of movement, perhaps combined with pivotal movement of the block between the Rhyolite and Pankey faults. The net slip of the Rhyolite fault must be considerable, since the throw is at least 200 feet.

The Pankey fault strikes about N. 40° E. and is nearly vertical. (See Plate III.) On the south side of Springtime Canyon the fault consists of a zone of interlocking joints, and it dies out altogether in brecciated brown rhyolite porphyry about 800 feet from the bottom of the canyon. On the ridge between Springtime and Roberts Canyons, nearly 3,000 feet from the southwestern end of the fault, the throw is about 400 feet, suggesting a marked pivotal movement. The fault can be traced across Roberts Canyon, where it brings the porphyritic rhyolite cap-rock to the floor of the canyon opposite unaltered rhyolite porphyry. The southeast side is the downthrow side.

North of the windmill in Nogal Canyon is a prominent fault which strikes about N. 75° E. and dips 80° SE. The throw of this fault is estimated at nearly 400 feet. Several subordinate faults are shown in figure 13, and doubtless others would be found by detailed study of the district.

ORE DEPOSITS

Inasmuch as only a negligible amount of development work has been done on any of the veins of the district, the following descriptive matter is based on observations made at or near the surface, chiefly at the Pankey vein.



NORTH SLOPS OF SPRINGTIME CANYON, SHOWING PANKEY FAULT AND VEIN OUTCROP

f-f-f, fault plane; a, porphyritic rhyolite cap-rock; b, discolored rhyolite porphyry, forming cliffs east of the fault; c, fresh flow-banded rhyolite porphyry; m, approximate upper limit of mineralization in the Pankey fault. The topmost point of the jagged vein outcrop as seen in this photograph is more than 300 feet lower in elevation than the base of the cliffs of discolored rhyolite porphyry to the right. About 25 feet of breccia and tuff lie between the two flows.

Photograph by A. H. Gunnell

The veins are of the type classified by Lindgren[1] as "epithermal deposits," which are characteristically developed in volcanic rocks and have no particular association with deep-seated intrusive bodies. They are branching and irregular fissure veins. (See fig. 15.) The vein matter is frozen to the walls and occurs in irregular stringers along a zone of inter lacing warped and discontinuous

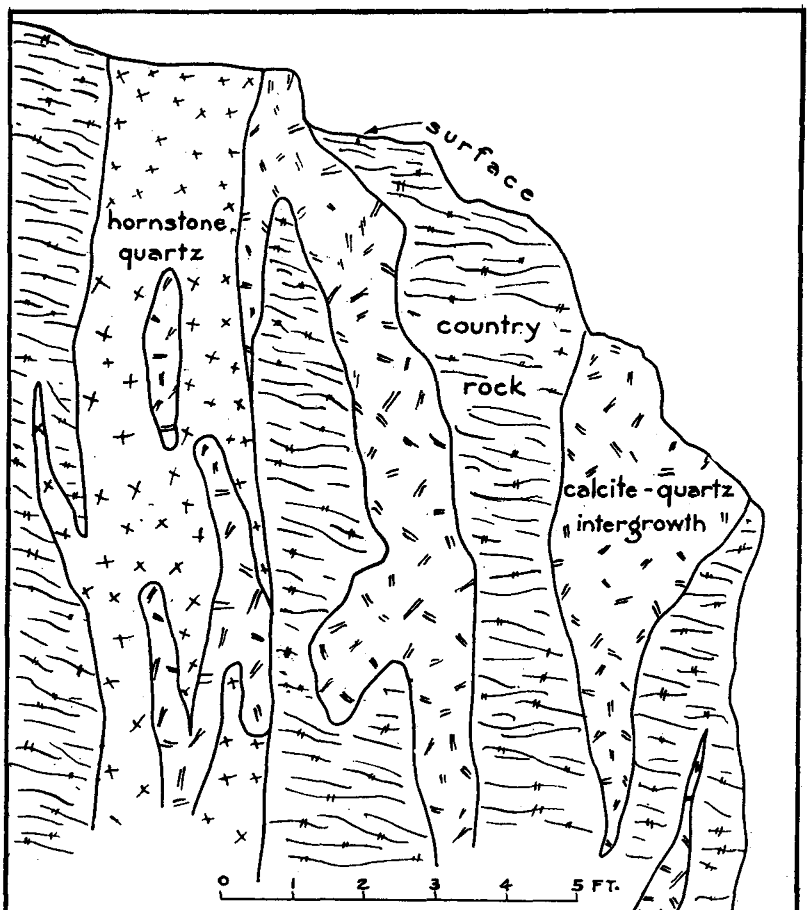


Figure 15.—Sketch of vein face, open cut, Pankey vein.

fractures and bands of cemented breccia. Brecciation is a prominent feature. Individual seams of vein matter range up to about 3 feet in width. The veins are rather tight. At the time of the writer's visit nearly every shaft in the district, regardless of topographic location,

[1]Lindgren, Waldemar, Mineral deposits, 3d ed., p. 516.

had water in the bottom, and this despite the fact that there had been no precipitation for some time.

Primary alteration of wall rock is slight. In places breccia fragments within the vein are thoroughly pyritized but carry only a trace of valuable metal. The rock exposed in the face of the north tunnel on the Pankey vein at a depth of about 95 feet has a chloritic tint.

The vein filling is essentially quartz and lamellar calcite. Most of the quartz is fine-grained hornstone of rapidly changing grain. Some of the denser varieties are cryptocrystalline. Delicate colloform banding and comb structures are prominent. Black and white cherts were noted in the Rhyolite vein on the north slope of Nogal Canyon. An intergrowth of quartz and lamellar calcite forms an important part of the vein filling, and a characteristic structure is conspicuous near the surface where weathering and oxidation have removed the calcite or differentially stained the intergrowth with iron and manganese oxides. The calcite lamellae range in size from microscopic laths to lamellae over an inch long and about one sixteenth of an inch thick. They are arranged in radiating groups or in such a manner as to enclose an irregular polygonal space which may or may not have been filled with quartz. Where still open the space is lined with innumerable quartz crystals. Black manganiferous calcite was noted in the Big It vein and forms almost the entire vein filling in the upper part. A subordinate amount of green and purple fluorite occurs in parts of some of the veins, apparently associated with the calcite. Manganese and iron oxides, though not abundant, are prominent locally in many of the veins and were in large part precipitated by the calcite of the vein matter. Pockets several feet long consisting of clay mixed with oxides of manganese and iron occur at places. Crests and coatings of pale sky-blue glassy allophane have grown on the quartz crystals in some of the vuggy ore.

The several varieties of quartz are generally confusedly intergrown, each variety grading into the others, and they are also intergrown with the calcite, but here and there it is possible to observe several successive phases of precipitation. Figure 16A is an illustration of banded ore from a small vein at the crest of the ridge south of the old sawmill camp in Nogal Canyon. This vein is 6 to 12 inches wide. The sequence of precipitation here is as follows: (1) hornstone quartz, (2) colloform banded quartz, (3) amethystine quartz, and (4) quartz-calcite intergrowth. The quartz-calcite intergrowth contains breccia fragments of the hornstone and in places cuts across the hornstone bands. The presence of breccia fragments of horn-stone, of wall rock, and of quartz-cemented breccia is a common feature of this part of the vein filling. Some of the breccia fragments seem partly kaolinized.

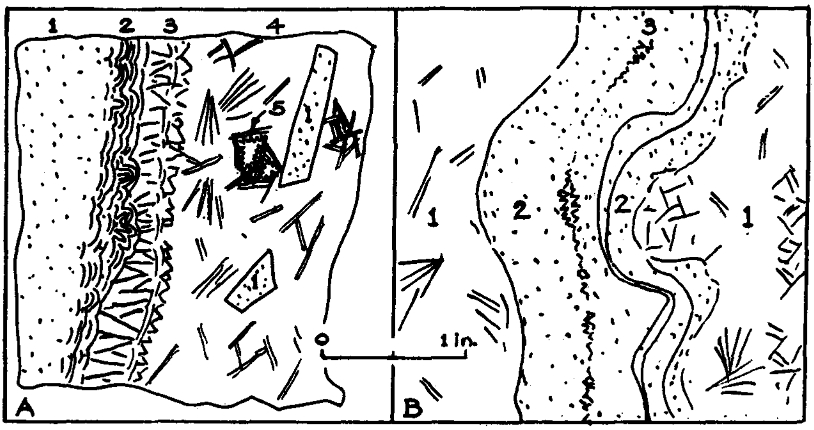


Figure 16.—A. Banded ore from small vein south of Nogal Canyon. (1) White to gray hornstone; (2) colloform-banded quartz; (3) amethystine quartz with faint banding; (4) lamellar calcite-quartz inter-growth; (5) comb quartz on quartz pseudomorphs of lamellar calcite. Note breccia fragments of hornstone in the calcite-quartz intergrowth. B. Ore from Pankey vein showing seemingly late hornstone. (1) Lamellar calcite-quartz intergrowth; (2) gray to green hornstone banded on one wall; (3) drusy center in the hornstone streak.

Figure 16B is an illustration of ore from the Pankey vein and shows a streak of banded hornstone in the calcite-quartz intergrowth. The drusy coarser center of the streak, and to a lesser degree the undulations of the banding, suggest that the hornstone filled a fracture in the other material. Cavities in the calcite-quartz intergrowth are lined with bristling comb quartz, some of which is amethystine, indicating beyond question a post-calcite phase of quartz deposition. Smaller scale structures and microscopic study also show this later phase and show that some of the post-calcite quartz is hornstone. Quartz pseudomorphs after calcite are common, and some of them are covered with quartz combs. (See fig. 16A.) Figure 17A shows incipient replacement of calcite lamellae by hornstone quartz and figure 17B shows slight age differences in the horn-stone itself.

It is estimated that metallic minerals constitute much less than 5 per cent of the vein matter. The valuable metals of the deposits are gold and silver. Native gold, native silver, cerargyrite, stephanite (?), and pyrite are the important minerals, and by far the most abundant of these is pyrite, even near the surface. Argentite, a common mineral in deposits of this class, was not observed. A trace of malachite is present, and analyses of the ore shipped from the Pankey vein show an

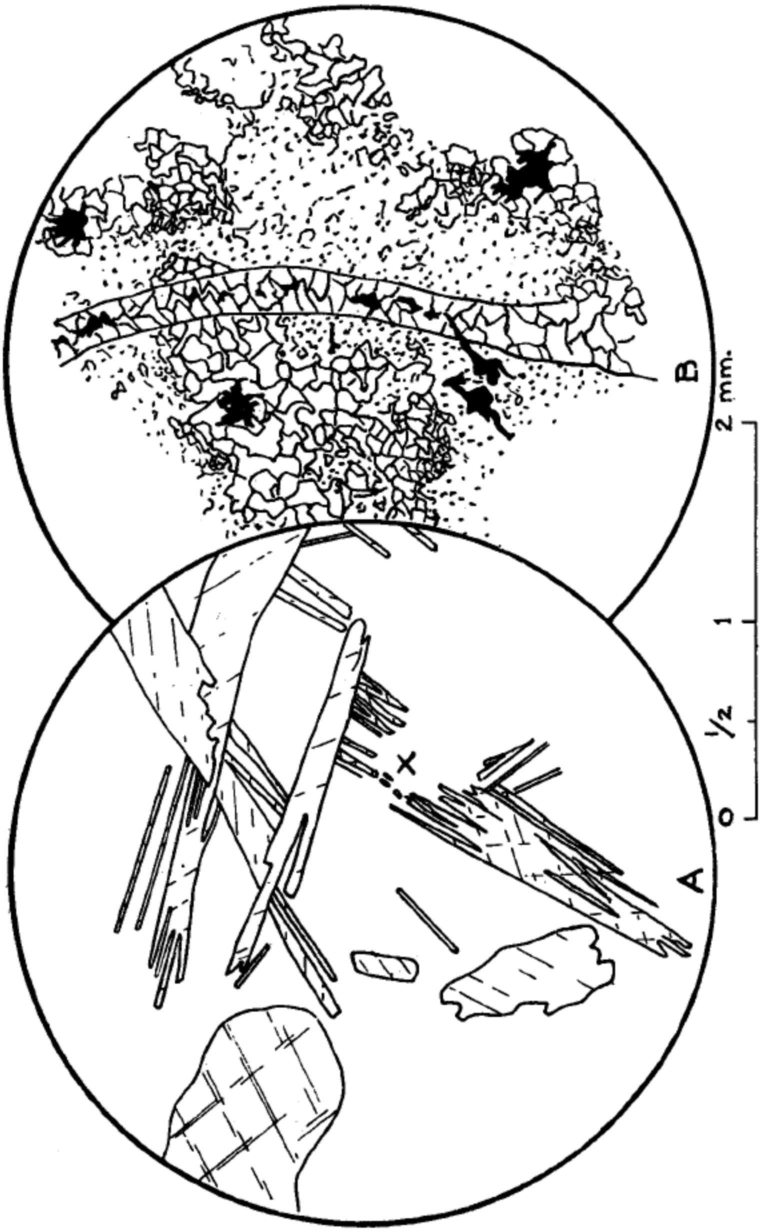


Figure 17.-Camera-lucida drawings of thin sections of vein filling from the Pankey vein. A. Calcite lamellae in vari-textured quartz matrix similar to that shown in Figure 17B. The lamellae at "X" are all members of the same optically continuous group partly replaced by quartz. Note the veinlet of coarse quartz both cutting and merging into the vari-textured material. Black areas represent gold, silver, limonite and manganese oxides.

average of about 0.03 per cent of copper. The metallic minerals seem to occur chiefly in dark bands and patches of the hornstone quartz, including the quartz intergrown with the calcite. The calcite itself seems barren, and the last stage of vuggy quartz precipitation is definitely so.

The primary minerals are pyrite, possibly stephanite (?), and a third unknown mineral from which the trace of malachite may have been derived. Pyrite can be seen easily in the partly oxidized ore. The stephanite (?) was observed only on polished surfaces of ore as particles of microscopic size almost completely replaced by native silver and gold. The native silver occurs as microscopic and larger particles interstitial to quartz grains, as coarse crystalline wires extending into drusy cavities, as veinlets cutting stephanite (?) and in inter-growths with native gold. (See fig. 18.) Several grains were observed with a core of corroded pyrite, indicating that pyrite as well as stephanite (?) had precipitated silver. The gold occurs as isolated particles and as intergrowth with native silver and limonite. In certain occurrences strings of gold follow the banding of the limonite (see fig. 18A), and this relationship suggests that the gold had been derived from the pyrite. Many of the gold-silver intergrowths distinctly show veinlets of gold traversing the silver. (See fig. 18, C and D.) The cerargytite occurs as a grayish-green stain or crust in the joints and checks of the vein and adjacent wall rock and as green blebs and waxy fillings in small vugs.

The ratio of silver to gold, as computed from smelter returns on 160 tons of ore shipped from the outcrop of the Pan-key vein is 25 to 1. As computed from 100 assays on representative and reliable samples from different parts of the Pankey outcrop and from the small amount of underground workings, this ratio is 30 to 1. The ratio ranges in different assays from 3 to 1 to 170 to 1. Assays as high as 59.28 oz. of gold and 821.6 oz. of silver per ton were obtained from picked samples, but these picked samples signify nothing concerning the grade of ore that may be mined, The average assay of all samples, exclusive of the picked ones, is about 0.225 oz. gold and 10.5 oz. silver per ton. This computed average checks well with the value of the ore that was shipped, which, after hand sorting, averaged 0.332 oz. gold and 8.4 oz. silver per ton. Assays of sorted and unsorted ore show an increase of about 40 per cent in grade on sorting. On this basis the ore shipped averaged as broken 0.237 oz. gold and 6.0 oz. silver, a further check on the average grade of the vein filling at and near the surface of the Pankey vein.

Although pyritization may extend into the wall rock, the valuable metals are confined to the vein filling, which is a characteristic feature of veins of this type. This has been checked

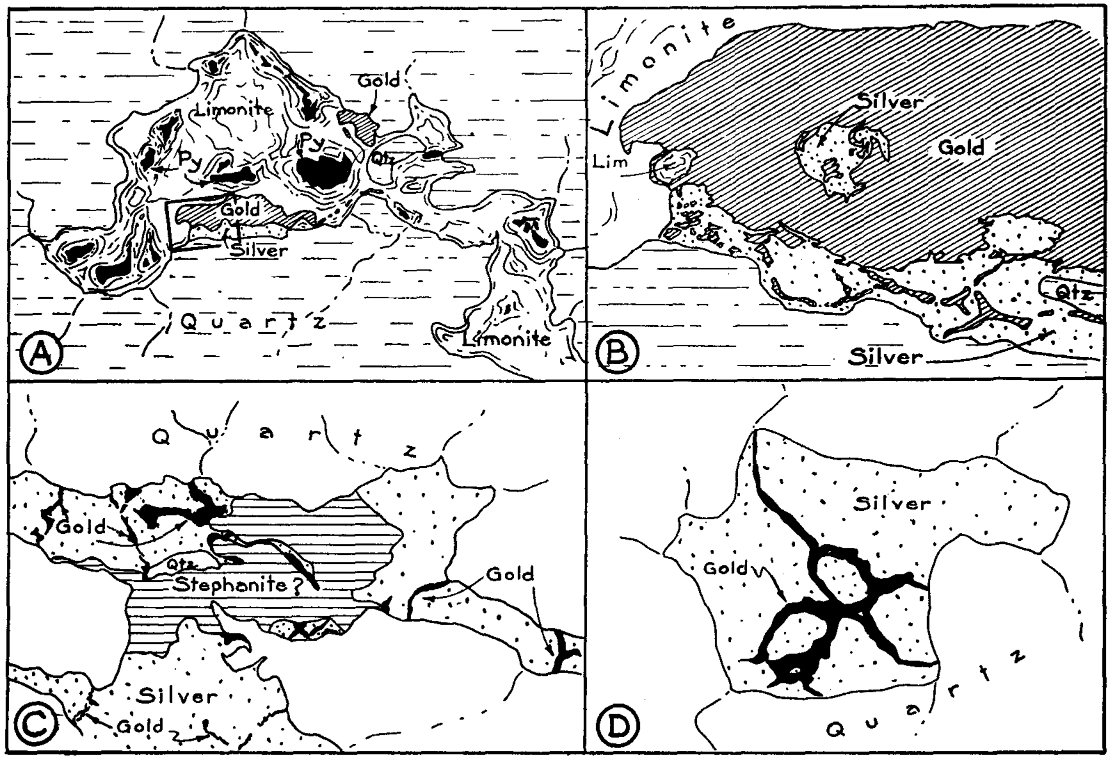


Figure 18.—Camera-lucida drawings of polished sections of ore from outcrop of Pankey vein. A. Gold and silver associated with oxidizing pyrite. Enlarged 85 diameters. B. Enlarg ed view of marked area in Figure 18A to show details of gold-silver intergrowth. Enlarged 625 diameters. C. Native silver replacing stephanite (?) and cut by veinlets of gold. Enlarged 625 diameters. D. Native silver traversed by veinlets of gold. Enlarged 625 diameters.

for this particular vein by examination of a few polished sections and by assays of the wall rock which show about 0.006 oz. gold and 0.60 oz. silver per ton. Assays on the Pankey vein show the presence of ore shoots of much higher grade than the average value of the vein, but development work is insufficient to indicate the extent or actual grade of these shoots. The average grade seems to be about 1.9 oz. gold and 30 oz. silver per ton, but the physical nature of the deposit makes considerable dilution in mining unavoidable.

Concerning the other veins of the district, very few of the assays as transmitted to the writer mention silver. Those that do, carry approximately the same ratio of silver to gold as indicated for the Pankey vein. The owners of the Rhyolite (Cordellia) mine state that the average of 140 assays on samples collected from the Rhyolite vein, presumably by them, from Milliken Park southward is about $6.00 in gold per ton. At the time of the writer's first visit to the Rhyolite mine, in 1929, prior to the present ownership, he was told that the veins as then sampled averaged about $3 per ton in gold. The geology of this part of the district suggests that these samples were from thin stringers or veins of less than minable width. The methods used in sampling at the Rhyolite mine and the vein widths represented were not reported. No samples were taken by the writer at this place. Evaluating all the veins of the district equally, it is estimated that the average value of the ore in and near the outcrop is about $5 per ton in gold and silver.

All the faults of the district and many of the minor fractures are mineralized, but it is noteworthy that mineralization is essentially confined to the brittle unaltered brown rhyolite and rarely extends more than a few feet into the upper discolored part, even though the fault continues strongly in this part. In the brown rhyolite porphyry the veins tend to form sharp and ragged outcrops. (See Plate III.) In the discolored rock, owing to the absence of vein filling, they can be detected only as intensely brecciated zones with an occasional streak of quartz. This is the case at the Rhyolite mine where the gold occurs in gougy, brecciated, iron-stained fault matter with essentially no other vein filling. It is reported that small high-grade pockets containing visible gold have been encountered at this place, but as a rule the presence of gold can be ascertained only by assaying or very careful panning.

Mineralization is even less evident in the porphyritic rhyolite than it is in the discolored rhyolite porphyry. Only at one place did the writer note any mineralization in this rock. This was on the Taylor property on the south side of Nogal Canyon. At some few places mineralizing solutions have spread out along the tuff at the contact with the cap-rock and have deposited lenses of white quartz which show here and there the typical lamellar structure of the main part of the main filling. One such lens is associated with the showing of mineralization in the cap-rock on the Taylor property, just mentioned ; another is associated with the Pankey vein.

POSSIBILITIES

Inasmuch as only a negligible amount of development work has been done on any of the veins of the district, their characteristics below the outcrop can only be inferred. The Pankey vein is one of the best exposed veins in the district, and it may be taken as an example in evaluating the possibilities of the deeper parts of the other veins. Changes in the grade of ore usually depend on one or more of the following: (1) A change in the grade of the primary ore, owing either to the presence of rich shoots or to a change with depth; (2) residual enrichment at or near the surface by leaching out of worthless minerals; (3) impoverishment at and near the surface by solution of the gold and silver; and (4) enrichment below the zone of solution by precipitation of the metals dissolved higher up.

Changes in the value of the primary ore of the district can be ascertained only by actual exploration. The primary ore is not uniform in metal content in all parts of the vein. Comparatively rich shoots are unquestionably present, but their location cannot be predicted. It can only be stated that they are probably very irregular in form. General changes in the grade of any particular vein will doubtless be gradual. According to Lindgren,[1] in veins of this type the gangue minerals continue in depth, but the ore becomes too low grade to mine.

It seems likely for several reasons that appreciable residual enrichment has not taken place. The quantity of valueless leachable vein matter is comparatively small; removal of the soluble matter that is present has been insignificant, since it may be observed at a number of places at and very near the surface ; and the rapid erosion of the district would remove any residual material practically as fast as it could be formed. There are, it is true, depressions formed by leaching of vein matter in the outcrop of the Pankey vein which show abnormally high assays presumably due to residual concentration, but these depressions are not extensive.

It is still more likely that solution and transportation of gold to lower levels has been negligible. This process requires an acid environment, abundant manganese oxides, a moderate amount of chlorine, a permeable vein and slow erosion. Manganese doubtless is present in adequate quantities, and the cerargyrite proves the presence of chlorine, but other necessary conditions are lacking.

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[1] Lindgren, Waldemar, Mineral deposits: 3d ed., p. 529, 1928.

Oxidation of pyrite is essential for the formation of much acid. Pyrite is not particularly abundant in the veins of the district, judging from the parts open to observation, and even under the best conditions could not yield a great supply of acid. Actually it has not yielded the full potential supply, since unoxidized pyrite exists practically at the surface. Furthermore, the presence of fresh calcite at and within a few feet of the surface indicates that the small amount of acid that may have been formed did not penetrate deeply. Where calcite is sufficiently abundant to neutralize effectively the acid as it is formed, the solution of gold may be entirely prevented, even though manganese and chlorine are present.[1] This in part seems to have been the case in the Pankey vein.

The veins in general are tight. Surface solutions have penetrated only along particularly permeable parts, and only if these permeable parts were devoid of calcite could the downward moving solutions have transported much gold. The downward transportation of gold obviously depends on the rate at which precipitating agents may act upon the solutions. In tight veins through which gold-transporting solutions must trickle slowly, precipitating agents would have comparatively full opportunity to react. It is known that feldspar and rhyolite glass will reduce acidity, and that native silver, which is 25 times more abundant than gold in the Pankey vein, and nearly all sulphides including pyrite will precipitate gold readily. Thus even in those parts of the vein poor in calcite, migration of gold would be inhibited by breccia fragments of the wall rock, native silver and sulphides. The intergrowths of silver and gold as observed on polished sections (see fig. 18) prove that precipitation by this means has taken place.

The fact that the outcrop of a manganiferous vein is gold bearing suggests that solution and transportation of gold have not been active. According to Emmons[2], outcrops rich in gold are generally found in connection with non-manganiferous deposits, but regardless of other factors, when erosion is sufficiently rapid to keep up with or overtake oxidation, auriferous outcrops may form from manganiferous lodes. The results of rapid erosion are threefold; (1) it removes pyrite before this mineral can produce the sulphuric acid that is essential for solution of the gold, (2) it removes the gold-bearing rock before the dissolving agencies can come into play, and (3) where leaching of valueless material may go on faster than solution of the gold it is likely to remove the enriched residual vein matter as quickly as this is formed. The topography of the district indicates definitely that erosion has been rapid, and that it has

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[1]Emmons, W. H., The enrichment of are deposits: U. S. Geol. Survey Bull. 625, p. 311, 1917.

[2]Idem, p. 316.

nearly kept pace with oxidation is proved by the presence of residual kernels of pyrite and other fresh vein matter essentially at the surface. Where the gold is locked up in the pyrite, as seems likely in this district, incomplete oxidation of the pyrite is further evidence against removal of the gold, since both the essential acid and the gold are liberated only by oxidation of the pyrite.

In the above paragraphs only migration of gold has been discussed, but since in the Pankey vein silver is almost as valuable as gold and under normal conditions would be more valuable, it is important to consider to what extent silver has migrated. Silver is readily dissolved by sulphuric acid and ferric sulphate, both of which are formed by oxidation of pyrite, although in arid and semi-arid climates considerable silver may be fixed at and near the surface as cerargyrite, as it has been in the Pankey vein. Thus the statements concerning rapid erosion and oxidation of pyrite bear upon the migration of silver as well as of gold. Some of the ways in which silver may be precipitated are by decrease in acidity of the solution and by contact of the solution with certain minerals that precipitate the native metal. The presence of calcite and the tightness of the veins thus mitigate against silver migration, although not to the extent that is true for gold. Pyrite can precipitate silver, and polished sections show that it has done so in the Pankey vein. So also has the stephanite (?). Below the zone of oxidation, secondary argentite and sulphosalts are precipitated. It is not known whether the silver sulphosalt stephanite (?) is secondary or primary in the Pankey vein. The specimens showing stephanite (?) were collected at an elevation of about 425 feet below the upper limit of mineralization. In most of its occurrences elsewhere stephanite is secondary, and if secondary in this case it indicates that this part of the vein was at one time an enriched silver zone below the zone of oxidation before erosion had been rapid, and that the overlying impoverished zone and most of the enriched zone have been eroded.

What has just been said leads to a consideration of that part of the district underlain by the bleached and discolored rhyolite porphyry. Since the veins are essentially confined to the brown rhyolite porphyry, any evidence of mineralization in the overlying discolored rock or in the porphyritic rhyolite suggests stronger mineralization below. The surface rock of almost the entire southern part of the district, roughly from Nogal Canyon southward, is discolored rhyolite in which traces of mineralization crop out here and there. The most prominent of these croppings occur along the Rhyolite vein. The presence of gold in these croppings, as reported to the writer, is encouraging. In this part of the district, where topography is less rugged, residual enrichment has probably taken place to some extent but may be balanced by the weak original mineralization in the fading upper edge of the vein. Few of the assays from this part of the district report silver, but this may be due to failure to assay for silver rather than to its absence. According to an assay map of the Rhyolite mine furnished by the owners, out of 30 assays only two reported silver. Placing face value upon the fact that the stephanite (?) in the Pankey vein may be secondary, it is possible that the veins in the southern part of the district may contain an enriched argentite-sulphosalt silver zone at a depth of several hundred feet. The presence of such an enriched zone would imply that the overlying part of the vein had suffered definite changes. At the surface the veins would be expected to carry chiefly gold and very little if any silver other than a little cerargyrite. The surface zone should merge downward into a zone in which native silver is prominent and this in turn should merge into an argentite zone containing stephanite, ruby silver and related minerals in the lower part. Gold should be equally important in all these zones. The possibility of silver enrichment suggests that the southern part of the district, where the veins are not deeply eroded, should be seriously considered as favorable prospecting ground.

It must be remembered that the possibilities advanced concerning the southern part of the district are based in part on inferences drawn from observations confined to surface features, and in part upon certain premises which may or may not be true. It is presumed that the Pankey vein is representative of all veins of the district in both grade and mineralogy, that the stephanite (?) in the Pankey vein is secondary, and that the permeable zones in the tight veins of the district are sufficiently extensive and numerous to have permitted the development of an economically important enriched silver zone. If any of these premises prove to be false, or if exploration does not show changes from the surface downward as expected, the possibility of silver sulphide enrichment should be discounted proportionately. Positive information could be obtained at a relatively small expense by diamond drilling. The holes should cut the vein at a depth of several hundred feet and at an angle of not less than 45°.

The depth to which the veins of the district may extend should be considerable. At the Pankey vein mineralization is exposed over a vertical range of about 550 feet, a ratio of exposed length to exposed depth of about 5.5 to 1. This ratio may be considered as a minimum expectancy for the veins of the district. The Pankey vein is still strong at the bottom of Springtime Canyon and should continue for several hundred feet below the bottom of the canyon.

The vein-like outcrops of flow rock such as those that are prominent in Springtime Canyon should not be overlooked as possible loci of fracturing, and therefore of mineralization. The Rhyolite vein and the Stevens vein in sec. 8 may have formed along such zones. However, mineralization does not necessarily imply the presence of valuable metals. The metal content of the veins may have been deposited during only a part of the vein-forming period, as suggested by the absence of metals in some phases of mineralization in the Pankey vein. It therefore follows that some of the veins which show seemingly typical vein filling may be nearly barren of valuable metals.

The possibilities of the San Jose district may be summarized as follows:

(1) In the Pankey vein and in other veins that have been deeply and rapidly eroded, it seems probable that the average grade of the ore below the oxidized zone will be approximately the same as that in the outcrop, although comparatively rich shoots doubtless occur in both the oxidized and primary zones. At a shallow depth there may be a slightly richer silver zone, particularly below the higher parts of the outcrops.

(2) In those veins whose upper part only is exposed, gold may increase slightly to a shallow depth, and valuable silver enrichment at greater depths is possible.

(3) Veins may occur in the district which do not outcrop, and some veins that outcrop with seemingly typical vein filling may be nearly barren of valuable metals.

(4) In the primary ore below the zone of possible enrichment any general changes are likely to be gradual, with an ultimate downward impoverishment, though gangue may continue.

(5) In the primary ore the valuable minerals are likely to be auriferous pyrite, a sulphosalt of silver containing a little copper, and possibly native gold.

(6) The depth to which the veins extend should be considerable.

TAYLOR PROSPECT

The Taylor prospect is in sec. 8, T. 9 S., R. 7 W., about 2 miles southeast of the old fort at Ojo Caliente on the southwest edge of the San Mateo Mountains. It is owned by Manuel Taylor of Hot Springs, N. Mex. The lower flows of andesite are exposed in the area near the mine. They are traversed by numerous dikes of diverse character, which are irregularly oriented.

The vein has been explored chiefly by a shaft 125 feet deep, from the bottom of which extends 95 feet of drifts along the vein in both directions. A crosscut 140 feet long driven from the bottom of the slope on the northwest is within hearing distance of the shaft and shows a little mineralization in the face. A large surface cut near the collar of the shaft exposes the full width of the vein. There are also a number of cuts on the vein to the southeast.

The ore occurs in a quartz vein which strikes N. 65°-70° E. and dips 75°-80° NW. The mineralized zone is fully 15 feet wide as exposed by the cut at the shaft. The wall rock here is a mottled greenish-gray rock which contains epidote and abundant chlorite. The rock was not examined microscopically, but in the hand specimen it appears to be propylitic andesite. Some of the rock fragments within the vein also have this appearance but most of these fragments are so highly silicified as to have lost their identity. At higher elevations the country rock appears to be rhyolite.

The ore is completely oxidized. The best of it occurs along the hanging wall in a vein 2 to 3 feet wide. The ore minerals are cerusite, chrysocolla, malachite and a little calamine. Limonite and manganese oxides are present. Lead is the chief metal in the upper part of the vein, but copper predominates at the bottom of the shaft.

A reported assay of some sorted ore is said to have given the following figures: 61.7 per cent lead, 1.2 per cent copper, and 13.4 oz. silver and 0.02 oz. gold per ton. No zinc was reported. No shipments have ever been made. The entire dump consists of ore which was extracted during development. All workings are along the veins. It is estimated that the dump contains about 500 tons. An average assay of this material would be considerably below the figures quoted above.

The appearance of the oxidized vein suggests that the original vein carried a moderate amount of sulphides. The depth to water level is not known, but oxidation probably extends for some distance below the bottom of the shaft. There seems to be a favorable opportunity at this place for the development at depth of a chalcocite zone which may be worth investigating.

NEGRO DIGGINGS

The "Negro Diggings" are in the southern part of the San Mateo Mountains and about 4 miles southwest of the Rhyolite mine. 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 ruins of a furnace are in evidence, but the small amount of metal scattered on the ground near it is lead containing very little silver.

Some excitement was caused by the supposed discovery of important copper deposits at this place in 1887. The workings have been idle most of the time since that discovery, but small-scale operations have been undertaken at various times. The last work was done in the spring of 1929. Mineralization occurs in a wide northward-trending shear zone in andesite. The andesite is greatly sheared and much altered. The rather weak veins contain small amounts of copper carbonates. No commercial ore is in sight.

SOCORRO PEAK DISTRICT

LOCATION AND HISTORY

Socorro Peak is approximately 4 miles west of the town of Socorro. It has an elevation of about 7,280 feet and forms the highest point of the short northward-trending range known as the Socorro Mountains. The main part of the mining district is southeast of the peak and is low down on the east slope adjacent to the alluvium. Some prospecting has been done well up toward the crest and also for some distance to the north and south.

The silver ores of the district were discovered in 1867 by prospectors from Magdalena. It is reported[1] that these men found evidence of ancient workings. The district became the scene of considerable mining and prospecting activity by 1880, and a smelter and mill were constructed. Mining continued until about the middle nineties, when the principal mines were closed, coincidently with the decline in the price of silver. The mines have been worked sporadically since but with generally discouraging results. Production has been variously estimated at from $760,000[2] to over $1,000,000[3], but it is rumored that but little profit was ever derived. The latest mining was in 1922 and 1923 in an attempt to take advantage of the high price of silver under the Pittman act.

TOPOGRAPHY

The Socorro Mountains lie along the western edge of the Rio Grande valley. The eastern face of the mountains is rather steep in general and suggestive of the dissected fault-scarp front which is characteristic of the monoclinal ranges of New Mexico. This slope is capped by volcanic cliffs which culminate in Socorro Peak. About 2,000 feet west of the mines and south of the cliffs is an elliptical ragged hill which represents one of the volcanic vents.

The lower part of the eastern face of the mountains is dissected by numerous arroyos extending eastward toward the Rio Grande. In the southern part of the district these depressions are steep-walled canyons, but to the north they are broader and more shallow and

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[1]Tones, F. A., New Mexico mines and minerals, p. 111, 1904.
[2]Idem.
[3]Otero, M. A., Report of the Governor of N. Mex., p. 430, 1900.

floored with alluvium. The intervening ridges or spurs extend eastward for varying distances. The lower slopes of many of them are gentle, and some pass almost imperceptibly into the plain. Others jut boldly forward.

GENERAL SEQUENCE OF THE ROCKS

The geology of the Socorro Peak district is shown on Plate IV and figure 19. The Socorro Mountains are built up principally of Tertiary volcanic rocks and interlain sediments. These rocks rest upon a thick series of sedimentary rocks of the Magdalena group, which in turn overlie pre-Cambrian argillite. The whole sequence, in general, is tilted toward the west. A large mass of monzonite porphyry has been exposed in one of the prospects.

The earlier volcanic rocks were faulted, and some of the faults became channels through which later eruptions were emitted. Ultimately the full series of volcanic rocks was faulted in a complex manner, and some of the resulting fractures were later mineralized. Some of the veins have been faulted.

A number of flows of diverse character are exposed in the area mapped. Silicification and sericitization are prominent in most of the flow rocks, and in addition the ferromagnesian minerals have been almost completely resorbed or otherwise destroyed. As a result, identification of several rock types is difficult. Cursory microscopic examination indicates that rhyolite and trachyte (?) are the principal flows. These rocks with associated tuffs and breccias constitute nearly all the volcanic rocks exposed in the restricted area examined. Small patches of andesite and diabase appear locally, and latite is prominent in one small sector. The amount of andesitic material in the associated sediments suggests that andesite was more abundant and wide spread than the few exposures would indicate. The full series is complex and was not studied in detail, but the accompanying table shows the probable sequence, the oldest at the bottom of the column, with apparent thicknesses so far as observed.

Formations in Socorro Peak District

	Feet
Quaternary	
Alluvium, wash and talus	
Liabase dikes	
Tertiary:	
Flow-banded trachyte (?) with locally a few feet of shale near the base	350
White rhyolite sill	0-350
Conglomerate, sandstone, shale and clay	300
Andesite, end of flow exposed	0-50
Spherulitic rhyolite	800
Latite, intrusive (?) into breccias and tuff.	
Rhyolite breccias and tuff, with included local andesite flow and in-Truded by latite	20-350
Andesite, local flow in breccia and tuff	50

Andesite, overlain by few feet of sandstone and shale	75
Monzonite porphyry, does not outcrop	
Pennsylvanian:	
Magdalena Group	
Madera limestone	500
Sandia formation; may include Kelly limestone (Mississippian) at base	600
Pre-Cambrian:	
Argillite	

CHARACTER AND DISTRIBUTION OF THE ROCKS

PRE-CAMBRIAN ROCKS

Pre-Cambrian argillite crops out several hundred feet west oı Woods' tunnel in the bottom of a small canyon. It is a dense, heavy, grayish-green rock, and to Q11 appearances is identical with the argillite or "greenstone" af the Magdalena district which consists essentially of quartz, sericite and chlorite. Jointing is prominently developed, particularly in a system which dips eastward at a low angle. The outcrop is completely surrounded by strata of the Sandia formation.

SEDIMENTARY ROCKS

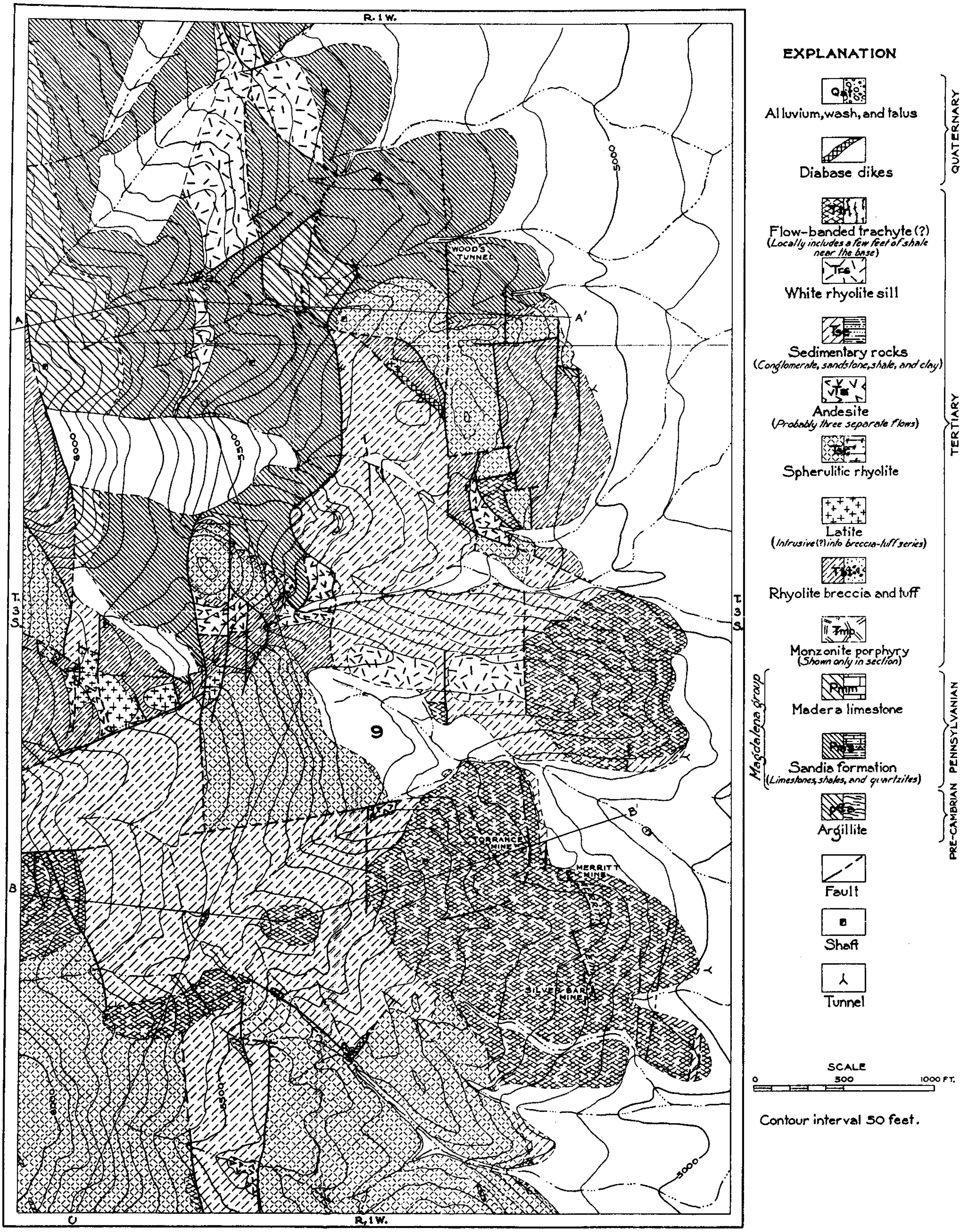
Pennsylvanian Rocks.—A considerable thickness of Magdalena (Pennsylvanian) rocks consisting of limestones, shales, and quartzites outcrops in a roughly T-shaped area on the long slope below Socorro Peak. These beds correspond to the Sandia and Madera formations of the Magdalena district which have been studied in detail by Loughlin, Koschmann and String-field. (See page 33.) They are strongly silicified along numerous fractures. The basal member of the series consists of quartzite which rests on the pre-Cambrian argillite. The beds just above the basal quartzite are covered by debris and not readily observable.

The bar of the T has a northerly trend and consists of a relatively undisturbed section about 1,100 feet thick which extends from the argillite westward to the base of the cliffs. The limestone is bounded at the cliffs by volcanic breccia. The Sandia-Madera contact is about 600 feet above the base. The beds extend southward until they are cut off by a complex system of faults which brings down the Tertiary rocks and at one place shows the lavas resting on the eroded surface of the limestone.

The upright of the T extends from the argillite eastward to the alluvium. The beds are overlain by volcanic rocks along the southern edge of the upright.

The general dip of the strata is 20° to 30° west, but east of the argillite the dip is rather erratic both in direction and amount, presumably as the result of fault tilting.

Tertiary Sedimentary Rocks.—Tertiary sediments constitute about a third of the exposed rocks in the Socorro Peak district. They form an



Topography by W.C. McLoughlin

Geology by S.G. Lasky

RECONNAISSANCE GEOLOGIC MAP OF THE SOCORRO PEAK DISTRICT

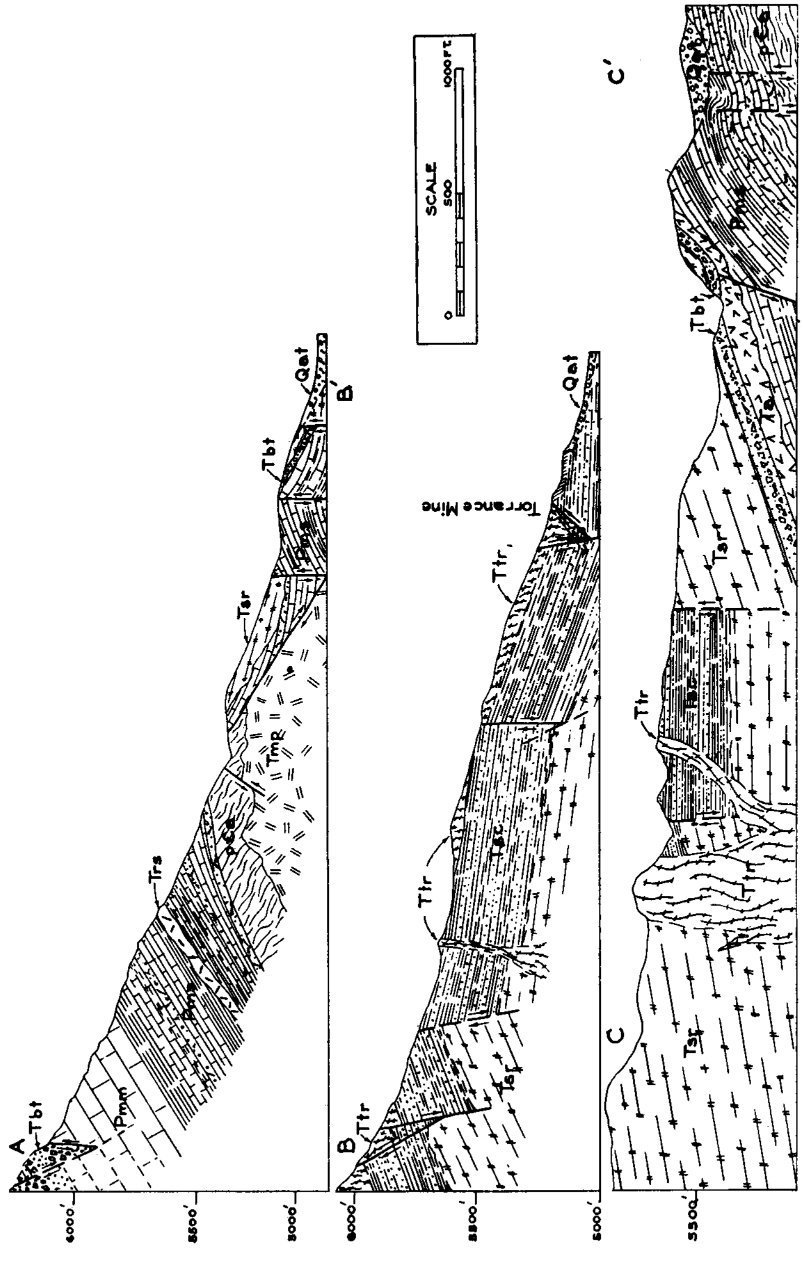


Figure 19.—Geologic sections of the Socorro Peak district. See Plate IV for explanation of patterns and location of sections.

almost continuous exposure from the limestone area to beyond the southern edge of the mapped part of the district. Even where the continuity of exposure is broken, it is obvious in most cases that the sediments extend beneath the surface rocks. They consist of conglomerate, sandstone, shale and clay, apparently largely derived from the volcanic rocks of adjacent slopes in the intervals between igneous activity. Some of the Shales and clays consist chiefly of volcanic ash. Most of the strata show water sorting, and cross-bedding is prominent in some of the more sandy layers.

The highest exposed part of the series consists of coarse conglomerate which is made up largely of angular fragments of volcanic rocks. It resembles volcanic agglomerate except that the matrix consists of sorted rounded grains, and thin sandy streaks are present. The conglomerate becomes finer in the lower beds and passes into a series of sandstones and shales.

The conglomerate is confined to the northern part of the district and lies south of the limestone tongue where it forms the crest of a prominent knob. A thin slice of the same material occurs on the opposite slope to the south. The beds south of the conglomerate consist predominantly of sandstone with subordinate shale, but farther south fine sand, shale and clay gradually increase in proportion until only a few of the coarser beds are present. Fragments of pumice were noted in some of the shale beds in the southern part. Many of the beds are ark osic.

The sandstones, shales and clays range in color from purple to bluish-green and gray. The shale and clay in places are streaked erratically with these colors. The clay occurs in thick beds and seems to have resulted from the alteration of shale and fine sand.

At least three series of these sediments have been noted. The earliest consists of a few feet of purple andesitic shales and sands upon the basal andesite flow. The second is about 300 feet thick and includes most of the exposed Tertiary sediments. It represents a rather extended period of quiet between the two major flows. Chozolate-colored clay forms the top of this series in the vicinity of the mines. The latest series consists of a few feet of gray shale about 20 feet above the base of the banded trachyte at the western edge of the map.

IGNEOUS ROCKS

Monzonite Porphyry.—No intrusive rocks other than those of the volcanic series outcrop in the Socorro Peak district, but a large m iss of monzonite porphyry is exposed in Woods' tunnel in the sedimentary area. The mass thus exposed is at least 700 feet long and 400 feet wide, with the faces of the workings still in monzonite. The only observable contact with other rocks is a fault contact with the Sandia formation, but from structural conditions it appears that the monzonite is intrusive chiefly into argillite. (See fig. 19, sec. A-A.) Monzonite appears on the dump of a shaft in the limestone some distance to the west, but no argillite is present, and presumably the monzonite reached into the limestone at this place.

The monzonite is a mottled greenish rock containing phenocrysts of pink and white feldspar. Under the microscope it is seen to contain about 10 per cent of interstitial quartz. The plagioclase is andesine, about An_{32}. The feldspar is strongly sericitized, and veinlets of sericite cut the rock. A little chlorite and veinlets and scattered grains of epidote are also present.

Andesite Porphyry.—Andesite porphyry appears in a few small areas where erosion has cut deeply or faulting has brought the lower flows near the surface. The weathered rock ranges in color from a purplish-gray to a dirty lavender. No fresh rock is exposed. The feldspar phenocrysts seem to constitute about 40 per cent of the rock in the hand specimen and form white chalky splotches in a partly crystalline groundmass. They range in size and shape from laths 2 to 4 mm. in length to irregular corroded fragments up to 3 or 4 mm. across. A characteristic feature of the rock is the presence of a few scattered phenocrysts of bronzy biotite. This feature is clearly recognizable in the less altered parts of the rock.

No ferromagnesian minerals were noted in thin sections, but the rock is thoroughly sprinkled with grains and lathlike areas of iron oxide probably derived from original ferromagnesian minerals. Numerous cavities bordered by a fringe of magnetite and having square or oblong outlines with truncated corners suggest the former presence of abundant augite.

Three flows of andesite seem to be present in the district. In the first canyon north of the Torrance mine andesite porphyry is exposed resting on an eroded limestone surface. It contains numerous rounded fragments of limestone, some of which appear baked or epidotized. The volcanic rock grades upward into andesite conglomerate and thence into a few feet of purple shale and fine sandstone which probably represent original andesite tuff. The thickness of the andesite, including the overlying shale and sandstone, is about 50 to 75 feet.

A second flow is indicated by three outcrops of andesite in the thick shale-sandstone-clay series. West of the Torrance mine and in the same gulch is a small mass overlain by sandstone and shale. This exposure is probably at the end of the flow. The rock grades from a porphyry of normal appearance into a mass containing large boulders of rhyolite. It then grades through successive stages into a breccia or conglomerate which is overlain by sandstone. About 1,500 feet to the south is another outcrop of andesite at about the same elevation and with the same stratigraphic relationship. The third exposure is near the southern edge of the mapped area.

A third flow of andesite is suggested by two other outcrops, one of which is overlain and the other underlain by rock of the tuff-breccia series. They are some distance apart, one being at the western edge of the mapped area and the other at the east foot of the mountain, and the relation between them may not be as simple as suggested.

Breccia and Tuff.—Rhyolite breccia and tuff form a series from 20 to 350 feet or more in thickness. This rock forms the foot of the mountain about midway between Woods' tunnel and the Torrance mine. In the first canyon north of the Torrance mine breccia lies upon the basal andesite flow and is itself overlain by spherulitic rhyolite. The breccia is about 50 feet thick here. The basal andesite flow is missing to the northeast, and only about 20 feet of breccia intervenes between limestone and rhyolite.

The breccia-tuff series continues westward from the canyon exposure noted above to beyond the edge of the map, but it is so broken by faults that its thickness in this vicinity is not readily determinable. It is estimated that this thickness is at least 350 feet. The series consists essentially of breccia in its lower part and tuff in its upper part. The less altered breccia is a pale lavender. The lavender-colored groundmass is apparently rhyolitic in character. Minute quartz and glassy feldspar phenocrysts are common and are locally large and rather prom: inent. The breccia fragments, which constitute most of the rock, average about 4 or 5 mm. across. The smallest are hardly discernible, while the largest are about 4 or 5 cm. in diameter. The fragments differ considerably in character. Most of them are soft and completely altered. Less altered fragments have a streaky appearance suggestive of a flow-banded rock or of shreds of vitric tuff. Small dark siliceous fragments are prominent locally, and an occasional larger andesite fragment and some similar to the latite of the district may be recognized. Much of the breccia is bleached white.

The character of the tuff is best shown by the rock above the cliffs at the western edge of the district. The tuff here is a nearly white, gritty, porous rock containing numerous fragments of quartz and greenish kaolinized material in a chalky vari-tinted groundmass. A few retained crystal outlines indicate that at least some of the green material was originally feldspar. Small rock fragments are present but are not common.

Latite.—Small irregular masses of latite appear at several places in the tuff-breccia area. The relation of the latite to the other rocks is obscure; both intrusive and fault contacts were observed. Still other contacts are indefinite and of uncertain character. At one place the latite seems to have come up through a fissure in the breccia and to have flowed out upon the surface.

As seen in the hand specimen, the latite contains a variable but always small proportion of dull white, medium-grained feldspar phenocrysts in a purplish-brown, lusterless, aphanitic groundmass. In thin section the rock appears to be composed of a few sericitized phenocrysts of plagioclase and orthoclase in about equal proportions, in a groundmass consisting of glass, feldspar microliter, magnetite, and lathlike aggregates of iron oxides. There are also a few prismatic sections of what may be serpentine pseudomorphs of augite. Secondary quartz is present as numerous veinlets and nests.

Spherulitic Rhyolite.—The major part of the volcanic rocks exposed in the district consists of fawn-colored, sandy-looking rhyolite porphyry which at casual glance is very like certain arkosic strata of the Abo "Red Beds." The color of the rock varies somewhat.

The phenocrysts consist of abundant quartz and white tabular feldspar crystals in about equal proportions. All are fine or medium grained. A few of the larger feldspar crystals are in graphic intergrowth with quartz. The groundmass has a variable texture. It generally has an appearance of granularity but is not quite resolvable into crystallinity. Locally it is decidedly aphanitic and in places nearly glassy. Elsewhere it is highly spherulitic. At the south end of the district this rock has been altered to a chalky rock in which, however, the spherulites are still preserved.

In a thin section of one specimen quartz as phenocrysts and in the groundmass constitutes most of the rock. The feldspar phenocrysts consist of sanidine and oligoclase. The ground-mass is composed of quartz and feldspar spherulites in a matrix chiefly quartz with subordinate glass and magnetite.

The full thickness of this rock is not exposed, but it exceeds 800 feet. The rock is locally thinly bedded and in appearance is strikingly like a sedimentary rock. Several of the pseudo-beds are less than a foot thick. The lower part of the series contains a few foreign fragments and with a greater proportion of these fragments would resemble parts of the breccia series which underlies it.

Flow-banded Trachyte (?).—A thick series of flow-banded rock overlies the Tertiary sedimentary series. It was apparently the last rock to be extruded in the limited area under consideration and contains the principal veins of the district. It forms a prominent peak at the western edge of the district with the crest just outside the mapped area. The contact with the underlying sedimentary series is exposed at the base of this peak. A few feet of shale occurs locally near the base of the flow at this place.

The rock differs widely in general appearance. Flow-handing is always present but in a variable degree. Some parts are fairly massive, with banding only barely discernible on the freshly broken surface, though much clearer on a weathered face. Elsewhere the banding is so well developed that the rock breaks down into small flat disklike pieces. These pieces give forth a clear ringing sound when struck with another piece or with a hammer. A large part of the rock has an augen structure with the flow lines bending around inclusions of feldspar crystals, nests of quartz grains, or undeformed foreign fragments.

The most common color is lavender, but dull dirty purple and purplish-gray are also common. In some of the more banded rock alternate bands have different colors. The more massive rock is generally more constant in color, but in some places it is streaked in an erratic fashion. Locally the rock is mottled in hues of gray and purple.

Phenocrysts are usually sparse or absent, but they are prominent in places. Quartz phenocrysts are rare. Feldspar phenocrysts are most abundant in the more massive rock. Feldspar, quartz and biotite phenocrysts are all present in a patch of mottled rock near the top of a low hill west of the mines. The feldspar crystals are abundant, and twinning lamellae are clear in some of them. This is the only rock of this series in which biotite phenocrysts were noted, but minute black needles which microscopic examination shows to be in part altered biotite are present in the groundmass of nearly all parts of the series examined. These needles seem to be a diagnostic feature of the rock.

West-southwest of the mines are two hills which together form an elliptical mass about 800 feet long and 200 feet across. This mass represents a vent through which the flow-banded rock was extruded. The flow features in this mass are highly distorted, but near the edges they are roughly parallel to the walls of the vent. Banding is less conspicuous in the heart of the mass. At one place where the contact is clearly exposed the lava contains inclusions of the surrounding shale. A number of lava dikes occur in the neighborhood of the vent with their long axes directed toward it. The shale adjacent to some of these intrusions is highly silicified.

Cursory microscopic examination of the banded rock at the western edge of the district, and of some of the more massive rock from near the mines, shows that most, if not all, of the quartz is secondary and that this rock is probably a trachyte.

The essential minerals are orthoclase and a trace of albite or oligoclase. The accessory minerals are magnetite and apatite. The groundmass has a trachytic texture, showing fluxional alignment of faint feldspar laths around the phenocrysts. Ferromagnesian minerals are conspicuously absent, but aggregates of magnetite grains grouped in crystalline shapes and residual flecks of biotite indicate their former presence.

Near the base of the trachyte series in the vicinity of the mines is a layer that is decidedly different from the surrounding rock. It is exposed in the mines as well as on the surface. Banding is vague, and the rock breaks with a semi-conchoidal fracture. It contains a few feldspar phenocrysts and an occasional liquid-clear quartz phenocryst in a dense, dark-redbrown groundmass. It appears to grade into the banded rock.

When examined under the microscope this rock is seen to consist of about 10 per cent of andesine phenocrysts, some of which are zoned An_{32-46}, and a moderate amount of andesine microlites in a cryptocrystalline iron-stained matrix. This rock, also, contains numerous magnetite aggregates with residual flecks of biotite. Named on the basis of its phenocrysts the rock would be an andesite, but it seemingly grades into the trachyte (?), and this coupled with the presence of the typical magnetite aggregates suggests that this rock and the so-called trachyte are the same. If so, the potash of the one rock and the lime and soda of the other are contained in the matrix, and the rock is intermediate between andesite and trachyte, i. e., a latite.

White Rhyolite.—A sill of white rhyolite porphyry lies in the Sandia formation about 200 feet above the base. Over 2,000 feet of its southern end lies within the mapped area; its continuation can be seen in the low limestone ridge to the north. It is at least 350 feet thick in the widest part examined. This thickness probably represents a deeper part of the sill brought to its present position by faulting. The continuation of the sill south of the fault zone has a lenslike outcrop about 750 feet long which at the southern end tapers almost to a point.

In its thicker part the sill contains quartz phenocrysts in a white porcelaneous groundmass. Flowbanding is prominent locally in alternate dense and quartzy bands, with scattered quartz phenocrysts, some of which form "eyes" in the banding. Other "eyes" consist of previously consolidated fragments of the same rock and of small drusy cavities. At the southern tapered end of the sill the rock is finely banded as the result of slight variations in texture, and some of it is leached and porous. No phenocrysts are present in this part. Southeast of this place is a thin lenslike outcrop of similar material in the shale-sandstone series. Similar rock, which is locally ropy in structure and which seems to have been brecciated and leached, covers the crest of the shale-sandstone ridge north of the Torrance mine.

Diabase.—Diabase dikes occur at several places in the district, probably representative of the basalt flows which lie to the south. They are not clearly exposed, and their presence has been partly inferred from the "[redacted]-heads" which result from weathering of the rock. Their location appears to coincide with faults.

STRUCTURE

FAULTS

In general the rocks of the district, both sedimentary and volcanic, dip westward. At some places near the foot of the mountain the rocks dip eastward or in some other direction, but this anomalous attitude is probably the result of fault tilting.

The east face of the mountain is complexly faulted. There are two general groups of faults, but the faults in each group so differ from each other in strike and dip that the groups can hardly be classified as systems. The most prominent group strikes northward parallel to the elongation of the mountains, and in most cases dips steeply. The strike of this group varies from N. 20° W. to N. 15° E. The second group strikes eastward transverse to the range and also, in general, dips steeply. The strike varies from about N. 70° E. to about S. 60° E.

The most prominent fault of the northward-trending group, and perhaps the most prominent of the district, brings the Sandia formation down against pre-Cambrian argillite. It strikes N. 2°-18° W. and dips to the east at 35°-55°. To the south this fault drops Tertiary sediments against the Sandia formation, but it cannot be traced farther south into the volcanic area. The throw of this fault is not less than 400 feet.

A second fault of this group separates the Madera limestone from the volcanic breccia at the foot of the cliffs below Socorro Peak. This fault strikes N. 5°-10° W. and dips about 75° W. A few small faults of the other group occur in the northern part of the district and displace members of the longitudinal group.

A few faults of the longitudinal group occur in the volcanic area to the south, but they are subordinate to the faults of the transverse group just as in the limestone area the transverse faults are subordinate to the others. One of the transverse faults which displaces members of the other group later became a channel through which some of the trachyte reached the surface. The rock of the vent is also faulted, and patches of trachyte occur as dikes along some of the faults of the vicinity.

STRUCTURAL HISTORY

Part of the structural history of the district may be interpreted from the features in the vicinity of the vent. Apparently the longitudinal faults were the first adjustments. These were broken by faults of the other group, some of which later became channels for the extrusion of lava which probably covered the earlier faults. The latest lavas were faulted by further adjustments. Carrying the story one step farther back than is indicated at this one place, it is not unreasonable to suppose that some of the early faults shown in the limestone area were covered by the first flows. Later adjustments may or may not have taken place along the same faults. Although the longitudinal group may be considered the earlier, undoubtedly some of the later movements took place contemporaneously along both groups.

The southern end of the district, where the transverse faults are best developed, is near the center of volcanic activity, and these faults may be the result of adjustments incident to that activity. If this adjustment decreased with depth, as seems likely, its effect upon the earlier group of faults would be less at depth than near the surface. This would explain the slight effect of the transverse faults upon the other group in the limestone area from which considerable overlying volcanic rock must have been eroded, and the comparatively great effect of these faults upon the few members of the other group in the volcanic area from which much less material has been removed.

The relationship of the faults of the longitudinal group to each other and to the different rocks exposed suggests that these faults are part of a wide shear zone, the center of which lies east of the mountain under the alluvium. (See fig. 19, sec. AA.) The net throw of this shear would be at least 1,250 feet, and this itself might be only an element in the stronger shear which developed the Rio Grande trough. The tilting of the strata to the west and the development of this shear would be part of the regional tilting and formation of monoclinal ranges as described by Lindgren.[1]

MINE WORKINGS

Figure 20 shows the principal mines and prospects in the main part of the district. These contain about 5,500 feet of workings, distributed approximately as follows:

Torrance mine ……………………	950 feet
Merritt mine …………………..	1,250 "
Silver Bar mine ……………….	670 "
Boarding House tunnel ………	1,350 "
Byerts tunnel …………………	1,280"

Other workings in the district have at least an equal footage.

[1]Lindgren, Waldemar, op. cit. (Prof. Paper 68), p. 25.

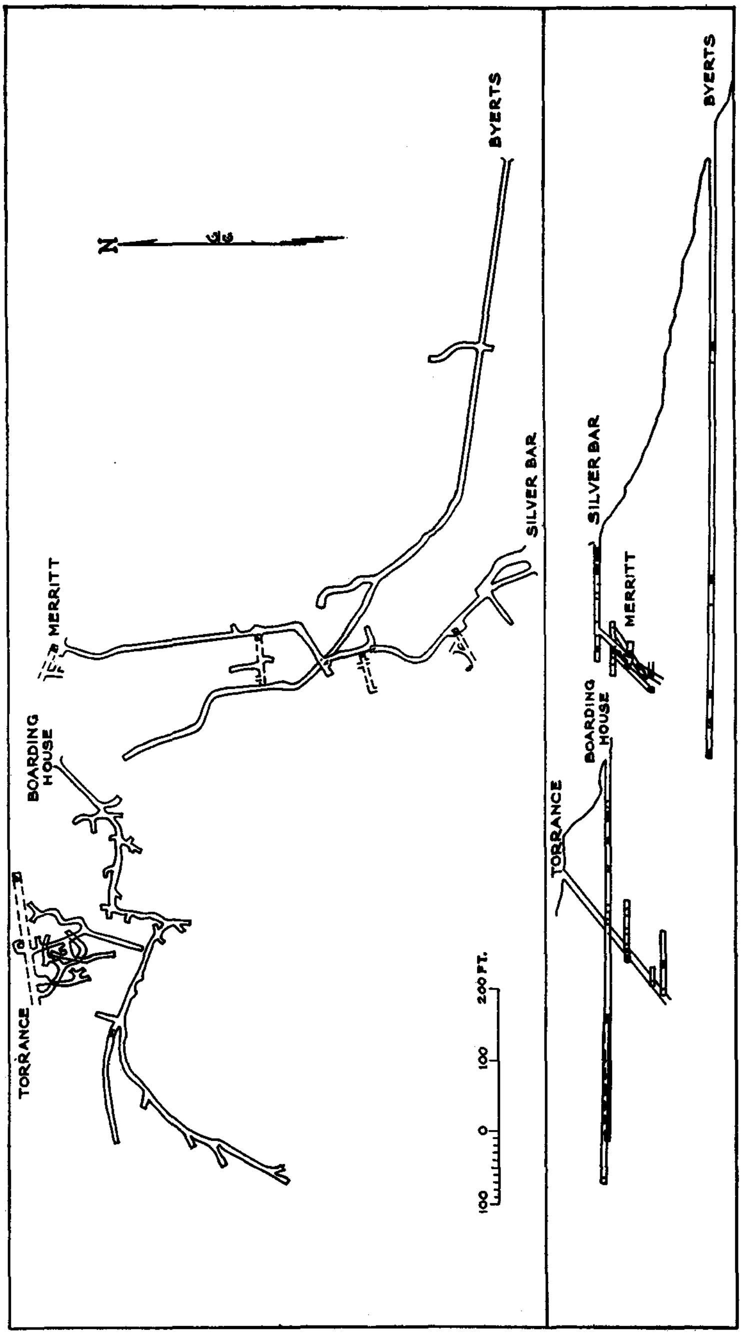


Figure 20.—Principal mines and prospects in the main part of the Socorro Peak district, plan and projection.

The important mines were the Merritt and the Torrance. Incline shafts and winzes were sunk along the vein, and levels were driven from these at suitable intervals. The Boarding House and Byerts tunnels were driven for prospecting purposes. Woods' tunnel to the north and the Gleeson prospect in the higher volcanic slopes to the west are the most extensive workings outside of the central part of the district. Other important but inaccessible workings occur in the limestone area and along the border of the volcanic vent described, in addition to numerous minor pits and adits.

ORE DEPOSITS

Most of the faults of the Socorro Peak district are moderately mineralized. Some mineralization occurs along nearly every fracture, but it is meager in most cases. Barite is the most abundant mineral. The veins occur chiefly in trachyte, spherulitic rhyolite and limestone.

The Merritt and Torrance veins were the only commercially productive veins of the district. They are in the trachyte (?) near the eastern edge of the mountain and may be faulted segments of the same vein. They strike nearly north and dip 35°-65° W. The Torrance segment lies in a down-faulted wedge between two northward-trending faults which dip toward each other, one about 50° W. and the other about 80° E. (See fig. 13, sec. BB.) The vein is lost in the wedge at the contact of the trachyte with the chocolate-colored clay which forms the top member of the underlying Tertiary sediments. This contact is about 125 feet below the surface and dips about 10° to the east. The sediments extend to the surface along the eastern fault and nearly so along the western fault. A short drift into the north wall of the shaft on the first level discloses much fractured rock of the clay series, so presumably the vein has been cut off here. There are no other workings in this mine north of the shaft.

A little mineralization occurs along the faults slightly below the level of the trachyte-clay contact and also along what seems to be a bedding contact between the clay and an underlying sandy bed.

The trachyte-clay contact in the Merritt mine is near the bottom of the shaft, approximately at the same elevation as in the Torrance mine, and the Merritt vein also is lost at this contact. About 325 feet from the portal of the Merritt adit the vein is displaced 50 feet to the west by a fault which strikes east-northeast and dips 75° north. The vein can be traced for about 800 feet south of the Merritt portal. The Silver Bar mine is on this vein.

The ore of the Torrance-Merritt vein consists of a small quantity of silver halides and a trace of malachite in a gangue which is chiefly barite and quartz. Fluorite, calcite and manganese oxides are also present. The best ore is said to have occurred where fluorite was most abundant. Most of the ore has been mined from both the Torrance and Merritt mines. The average silver content of this ore is said to have been about 15 or 20 ounces a ton. Sampling of the Merritt mine for private reports shows that the silver content of the remaining ore ranges from about 2 to 7.5 ounces a ton and the gold from about 0.02 to 0.25 ounces.

Mineralization in the northern part of the district is most abundant near and along the argillite-limestone and limestonebreccia fault contacts. The gangue is chiefly barite, essentially the same as to the south. Lead, in the form of galena, is the chief metal present, but even it is insignificant. Galena, accompanied at one place by mimetite, also occurs in the veins near and along the volcanic vent west of the mines. Vanadinite, wulfenite and argentite have been reported.

Manganese oxides are locally plentiful in some of the veins of the district' and have been mined from several. The total quantity produced, however, has been insignificant. An outcrop of massive manganese ore, which has not been prospected, occurs along the limestone breccia contact at the foot of the cliffs.

POSSIBILITIES

The outlook for important future mining operations in the Socorro Peak district is forbidding. The cost of finding new ore bodies would be great, and any ore mined would require a higher silver content than formerly if the low current prices for silver should continue.

The principal ores of the district are apparently of the type associated with volcanic activity, called by Lindgren[2] "epithermal deposits." Some mineralization, particularly in the limestone area, may be genetically related to the monzonite intrusion revealed in Woods' tunnel. If so, it may possibly be worth while to investigate the border zones of this intrusion, but the exposed metallization close to the supposed source is so weak that prospecting for ore must be recognized as decidedly unpromising.

The ore mined from the Merritt-Torrance vein, the richest vein in the district, is said to have averaged from 15 to 20 ounces of silver a ton. This report seems reliable. The ore is characteristic of the upper oxidized zone of silver deposits, and it is impossible to say whether it is richer or poorer than the primary ore, none of which is exposed for comparison. Silver halide ores in many cases have experienced a

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[1]Wells. E. H, Manganese in New Mexico: N. Mex. Sch. of Mines Mineral Resources Survey Bull. 2, pp. 76-78, 1918.

[2]Lindgren, Waldemar, Mineral deposits, 3d ed., p. 516, 1928.

certain degree of enrichment, and if that is true in this case there is little incentive to search for the lower grade primary ore. Furthermore, according to Lindgren, ore of this type becomes poorer in the lower part of the deposits, though the gangue generally continues.

The continuation of the Merritt-Torrance vein along both strike and dip merits consideration. The vein dies out against the underlying clay. This clay, and the other clayey and shalt' members of the sedimentary series of which it is a part, apparently reduced and absorbed the stresses which produced the vein, much as ordinary shale is thought to do under similar conditions. The thickness of the series is estimated at about 300 feet, and it is doubtful if the vein continues on the other side. Some of the more sandy beds may be well fractured, and it is possible that they may have formed the loci for either primary or richer secondary ores. But even assuming that such ores exist, the cost of searching for them must be balanced against their probable value.

Although the vein may not extend from the trachyte (?) through the sedimentary series, the principal faults, along which the ore solutions probably rose, certainly do, and other veins undoubtedly occur in the underlying rocks. Possibly valuable ore bodies occur along these faults and veins and perhaps as a replacement of concealed limestones of the Magdalena group, but it is doubtful if such bodies would repay the cost of finding and mining them.

The continuation of the Merritt-Torrance vein north of the Torrance mine seemingly has been removed by erosion. The vein has not been followed to the south beyond the Silver Bar mine. The rock in this vicinity is cut by several faults and the vein may be displaced, but the displacement along these faults cannot be large since the underlying shales are exposed at several places. A shaft about 300 feet east of the Silver Bar portal is on a vein believed by some to be a faulted continuation of the Merritt vein. Consecutive faulting may have stepped the vein to the east under the alluvium, or the vein may die out in this vicinity by splitting, since in the Silver Bar mine it seems to be composed of more than one member.

It is possible that concealed ore bodies occur beneath the alluvium bordering the district on the east.

The barite veins of the district, which are numerous and high grade in places, may become commercially valuable at some future time.

DEPOSITS IN SANDSTONE

GENERAL REMARKS

The ore deposits of the "Red Beds" type in New Mexico

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[1]Idem.

and in the adjoining states for many years have offered material for conjecture and hypothesis, and a discussion of the difficult problem of their genesis is beyond the scope of this report. However, certain observations were made during the field work which differ in some respects from those given in some previous reports. Deposits of galena, so far as is known, have not been described in the literature on American deposits of this type, although cerusite has been mentioned.[1] A deposit of galena occurs in sandstone near copper deposits northeast of Socorro, and a more important deposit of this mineral associated with copper occurs in Abo (Permian) arkose a few miles east of Alamogordo, N. Mex.[2] An analysis of a 6-month composite sample from the Stauber deposit near Pastura, Guadalupe County, showed the presence of 1.7 per cent of zinc.[3] Seemingly, lead and zinc, as well as copper, were amenable to the processes which formed the "Red Beds" deposits. A number of writers have described the deposits[4] of this type, and a recent paper by Finch has brought forth considerable discussion.

DISTRIBUTION

The several kinds of deposits in the "Red Beds" occur in strata which range in age from Carboniferous to Cretaceous. In New Mexico the copper deposits are chiefly in the Permian Abo sandstone and to a lesser extent in sandstone members of overlying and underlying formations. The Abo formation is found in Socorro County at a number of places, but the copper deposits within it are confined to a belt which extends from about 6 miles north of Scholle in Valencia County, southward almost to Carthage, about 60 miles. The deposits are segregated into three districts; the district surrounding Scholle, the area west of Rayo, and an area northeast of Socorro.

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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. 149, 1910.

[2]Lasky, S. G., and Wootton, T. P., Metal resources of N. Mex.: N. Mex. Sch. Of Mines, State Bur. Of Mines and Min. Res. Bull. 7 (in preparation).

[3]Stauber, I. J., A sandstone copper deposit: Presented at the El Paso meeting, Amer. Ming. Cong., Western Division, Oct., 1930.

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

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Tarr, W. A., Copper in the “Red Beds” of Oklahoma: Econ. Geol., vol. 5, pp. 221-226, 1910.

SCHOLLE DISTRICT

Scholle is on the Belen cut-off of the Atchison, Topeka & Santa Fe railway, about 2 miles north of the Socorro-Valencia County line, and one mile west of the Torrance-Valencia County line. This town is near the center of the Scholle district, which extends southward into Socorro County. Faint showings of copper carbonates appear more or less continuously as far south as Rayo, about 12 miles distant.

Several mills have been built in the district to treat the ores, but they have proved unsuccessful and are now shut down.

The district produced a small tonnage steadily from 1915 to 1919, but production since then has been desultory. The latest recorded production' was for the year 1928 and consisted of 1,943 tons of ore containing 10 per cent copper, and an ounce of silver and a trace of gold to the ton. In October, 1929, the district was idle except for some one-man operations. The approximate entire production of the district, estimated from figures given in various copies of Mineral Resources, consists of 8,500 tons of ore carrying 1,075,000 pounds of copper valued at $224,000 and 6,700 ounces of silver valued at $4,700. Practically all of this production is credited to Torrance and Valencia Counties.

The deposits are similar in most respects to the general type of "Red Beds" copper deposits. The copper occurs as carbonates in the shale beds; as sulphides, chiefly chalcocite, in arkose associated with carbonized plant remains and fossil wood ; and as nodules and lenses of sulphides which are a replacement of the cement and feldspar of the arkose. Other nodules appear to represent secondary replacement of previous pyrite nodules, through a bornite stage. In some instances the chalcocite seemingly has filled cell spaces of the plant remains before replacing the cell walls. Chalcocite, covellite, chalcopyrite, bornite and pyrite represent the sulphides of these deposits.

RAYO DISTRICT

Rayo postoffice is about 12 miles south of Scholle in an area of Chupadera limestone. The copper deposits are west of Rayo and in the Abo sandstone not far from the limestone-sandstone contact. The main prospects are about 2 miles from Rayo, but numerous pits have been made both north and south of them. A number of dikes cut the limestone about midway between Rayo and the deposits.

Workings consist almost entirely of trenches and cuts. The ore consists of copper carbonates and nodules of chalcocite in a loosely cemented gray sandstone. Locally this rock is overlain by red sandstone which is barren. No carbonaceous matter was observed.

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[1]U. S. Bur. Mines, Mineral Resources, 1928, pt. 1, p. 557, 1931

At one of the prospects there is an abandoned mill containing a small steam engine, a jaw crusher and rolls.

CHUPADERO MINES

The Chupadero mines are about 6 miles northeast of Socorro and on the east side of the Rio Grande in sec. 26, T. 2 S., R. 1 E. Copper carbonates occur mainly in a thin-bedded sandstone layer within the Magdalena formation. The sandstone is overlain by blue limestone. Shale occurs locally between the sandstone member and underlying limestone.

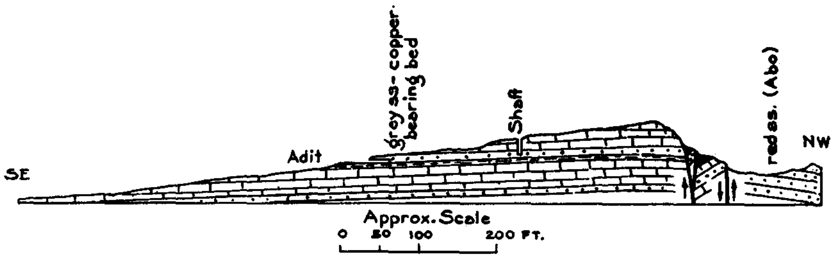

Figure 21.—Sketch section through the Chupadero mines, northeast of Socorro.

An adit about 30 feet long has been driven into the sandstone member where it outcrops on the approximate dip slope north of Arroyo de los Pinos. (See fig. 21.) A short distance up the hill a shaft collars in blue limestone and bottoms in the sandstone bed. On the other side of the ridge, which represents the scarp of a strong fault zone striking about N. 50° E., copper mineralization appears in sandstone within the fault zone. A little gypsum is present at this place in the vein, and some malachite has spread along the fault surfaces locally.

About a quarter of a mile south of the above deposit and just south of Arroyo de los Pinos, a short adit has been driven northwestward along carbonate mineralization in what appears to be the same sandstone member. This sandstone outcrops along a fault scarp.

LEAD PROSPECT

Galena, barite and fluorite occur in a calcareous sandstone member of the Chupadera formation about 3 miles north of the Chupadero mines and a mile west of Ojo de la Parida. The minerals occur as a replacement and as cavity fillings which are chiefly parallel to the bedding. The vein is from a fraction of an inch to 2 feet thick.

Mineralization also appears in the gouge of numerous fault slips which cut the sandstone. The adjacent limestone is only slightly mineralized. The galena occurs in bunches in the barite and barite and fluorite and as small isolated cubes in the sandstone. Barite is very abundant, but only a small quantity of fluorite is present. A trace of malachite was observed at one place.

The origin of the lead at the Lead prospect is possibly the same as that of the copper in the deposits of this type, but the mode of occurrence is somewhat different. The strong northeast faulting which has greatly disturbed the strata in this area was probably associated with a certain amount of movement parallel to the beds. The brittle sandstone member is much fractured, being opened up especially along the bedding planes. These openings later became filled with mineral matter which either used the minor fault slips as channelways of admission or else spread from the sandstone bed into the slips. It is noteworthy that within these slips minerals occur in the gouge itself in well-crystallized aggregates.

POSSIBILITIES

The following statements by Finch[1] seem to be descriptive of this type of deposit:

> The carbonate-silicate ores are not found in sufficient quantity in any one area to justify the erection of milling plants for their treatment. This has been tried at several points in New Mexico with failure as a result.
>
> A larger tonnage might be produced by mining carbonate and chalcocite beds together, but this would greatly reduce the grade if unaltered chalcocite beds were mined, since they are not in themselves commercial. * * * Direct smelting of sorted ore seems to be only method of making commercial recovery.
>
> No one district known to the writer promises to yield enough production to justify investment in a local smelter. The deposits lend themselves best to the purposes of the individual miner and leaser who can search for lenses of ore, and ship a sorted product to the custom smelters. Under favorable conditions he can make a small profit.

The above is based on the theory that the copper was derived from pre-Cambrian outcrops now eroded. Blanchard and Boswell,[2] who do not concur with this theory for all the deposits, believe that under certain conditions large commercial bodies of ore may have been formed.

JONES IRON DEPOSITS

The Jones iron deposits were not visited by the writer. They have been described by F. C. Schrader,[3] whose report has been drawn on for most of the following description.

The deposits are located along the old Carthage-Carrizozo highway, about 47 miles due east of San Antonio, a station of the Atchison, Topeka & Santa Fe railway 12 miles south of Socorro. The prevailing rock is Chupadera limestone with anticlinal structure trending nearly east and west. Along the crest of the small anticline is a dike of monzonite which has the same strike. It has a width of a

[1]Pinch, J. W., op. cit., p. 384.

[2]Idem, discussion.

[3]Lindgren, Waldemar, Graton, L. C., and Gordon, C. H., The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, pp. 203-205, 1910.

quarter to half a mile. The monzonite forms the entire crest and most of the slopes of the axial ridge. The limestone on the north side of the dike dips 50°-60°NNE.; on the south side the dip at the dike is nearly vertical, but it rapidly flattens to 20° SSW. on the low ridge south of the principal workings.

Magnetite, which is the chief ore mineral, occurs in irregular bodies along the contact of limestone and gypsum with the monzonite. Material[1] on some of the dumps suggests that iron in the carbonate form may be present in quantity in the deeper parts of the deposits. The limestone occurring with the iron appears to show little or no evidence of contact metamorphism.

Ore of commercial grade occurs along the contact for at least 3 miles, and the mineralized zone has a length of about 9 miles.

The iron ore on the south side of the dike near Jones camp is partly oxidized magnetite and is contained in an east-west belt about a quarter of a mile long and about 150 feet wide. There are two principal ledges in this belt. They are 10 to 40 feet thick and consist of massive beds of iron ore standing at steep dips, with some interbedded impure altered limestone or gypsum. They probably extend downward below the shafts, which are 30 to 40 feet deep. Between the iron ore and the fresh monzonite lies a zone about 40 feet wide in which the igneous rock is softened, altered and bleached. A small quantity of malachite and chalcocite is locally associated with the iron ore. The average ore is said to contain 60.59 per cent of iron, 2.53 per cent of silica, 0.152 per cent of phosphoric acid, and 0.203 per cent of sulphur.

Schrader makes the following statement regarding the extent of the deposits:

> The question of the extent of the ore must, of course, be settled by actual exploration. But it is proper to mention that if, as seems probable, the ore is the result of contact metamorphism of the limestone by the monzonite dike, the mineralization has probably taken place only in certain strata in the limestone. It is not likely that the ore will accompany the contact indefinitely in depth and it is not probable that the ore will be found in quartzite or shaly strata which may readily *be* conceived to underlie the limestone.

IRON MOUNTAIN DISTRICT[2]

The Iron Mountain iron deposits are located in the eastern foothills at the northern end of the Cuchillo Mountains in T. 9 S., R. 8 W., about 12 miles north of Fairview. They can be reached by way of Fairview, and it is possible to drive within a quarter of a mile of the tunnel.

The country rock consists of limestones intruded by an elongated body of porphyry which seems to have arched the

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[1]Wells, E. H., Personal communication.

[2]Ballmer, G. J., Santa Rita, N. M. Or al communication.

Smythe, D. D., A contact metomorphic iron-ore deposit near Fairview, New Mexico: Econ. Geol., vol. 16, pp. 410-418, 1901.

overlying rocks somewhat. Considerable contact metamorphism has occurred at the borders of the intrusion.

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 garnet also occurs in the ore. A little malachite is present. The average grade of the ore is about 45 per cent iron.

Smythe[1] makes the following statements concerning the probable extent of the ore bodies:

> No idea could be formed as to their extension in depth since, aside from a fifty foot tunnel, there are no underground workings. It seems possible, however, that they will not extend over a few hundred feet in depth since the metamorphic action appears to have been confined to the roof of the intrusion.

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[1]Idem, p. 418.

[illegible] MEXICO BUREAU OF MINES

[illegible] MINERAL RESOURCES