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MINERAL RESOURCES
OF THE
REGION AROUND BOULDER DAM

BY

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MINERAL RESOURCES OF THE REGION AROUND BOULDER DAM

By D. F. Hewett, Eugene Callaghan, B. N. Moore, T. B. Nolan, W. W. Rubey, and W. T. Schaller

INTRODUCTION

Authorization of the inquiry.—The inquiry concerning the resources of the area near Boulder Dam has been made possible by a grant of $25,000 from the Public Works Administration to the United States Bureau of Reclamation. From this sum $10,000 was allocated to the United States Geological Survey for a field study of the mineral deposits in the region of the dam. Later an additional sum was allocated to cover the cost of printing this report. A preliminary report[1] was issued in January 1935, about 7 months after the field work was completed.

Organization of field work.—In accordance with a common practice the mineral resources were considered in three groups—(1) the nonferrous-metal group, which includes the deposits that contain gold, silver, copper, lead, zinc, etc.; (2) the ferrous-metal group, which includes iron, manganese, tungsten, molybdenum, vanadium, cobalt, and nickel; (3) the nonmetallic group, which includes limestone, dolomite, gypsum, salt, borates, magnesite, brucite, celestite, sand, clays, etc.

The field work was assigned to the following geologists, chosen on account of training and previous experience in the general region. The dates indicate duration of the period of field work in 1934.

D. F. Hewett, ferrous-metal deposits; April 2 to May 16.

T. B. Nolan, nonferrous-metal deposits; February 26 to June 2.

W. T. Schaller, borate minerals in the Kramer district; February 27 to April 5.

W. W. Rubey and Eugene Callaghan, magnesite deposits of the Muddy Mountains and elsewhere, borate deposits; February 23 to May 17.

B. N. Moore, nonmetallic minerals; February 14 to May 24.

[1] Mineral resources and possible industrial development in the region surrounding Boulder Dam, 44 pp., U. S. Bur. Reclamation, November 1934.

Acknowledgments.—In anticipation of the field work, comprehensive card indexes for each mineral or metal were assembled from all material published or made available by State and Federal organizations, as well as private sources. Special acknowledgment should be made to the following persons for assistance in compiling this preliminary record:

G. M. Butler, director, Arizona Bureau of Mines and Geology, Tucson, Ariz.
W. W. Bradley, State mineralogist, division of mines, California Department of Natural Resources, San Francisco, Calif.
J. A. Fulton, director, Nevada State Bureau of Mines, Reno, Nev.
G. W. Malone, State engineer, Reno, Nev.
E. C. Hoag, industrial agent, Union Pacific Railroad, Omaha, Nebr.

The following publications were particularly helpful:

Arizona: Bulletins of the Arizona Bureau of Mines and Geology.
California: Reports of the State Department of Natural Resources (superseding California Mining Bureau).

Nevada:
Mining districts and mineral resources of Nevada, by F. C. Lincoln, 295 pp., Reno, 1923.
Metal and nonmetal occurrences in Nevada, by C. Stoddard: Nevada Univ. Bull., vol. 26, 129 pp., 1932.
Mineral resources of southern Nevada, by J. A. Carpenter: Nevada State Bur. Mines Bull., vol. 1, no. 1, 23 pp., 1929.
Natural resources for electrochemical industries in the Boulder Dam area, by A. M. Smith, Reno, Nev., Colorado River Comm. (unprinted).

Reports of the United States Geological Survey based on detailed and reconnaissance work in several districts within the region, and cited on later pages, greatly expedited the work.

Scope of the report.—The principal purpose of the inquiry was an appraisal of the mineral resources of the region with respect to their probable availability as the basis of industries that would consume power generated at Boulder Dam. Viewed broadly, this power could be consumed in either or both of two ways—first, by transmission from the dam to producing mines, where it could be used primarily as a source of mechanical energy; second, on the railroad near the dam, where it could be used as a source of either chemical or mechanical energy applied to raw materials brought there from nearby mines.

Early in the review of the problem it became apparent that not all the 500 or more mining districts or individual mines within 200 miles of the dam, an area of about 120,000 square miles, could be visited or examined with the time and personnel available. In choosing those districts that should be examined in considerable detail, those that could only be briefly examined, and those that must be omitted, consideration was given to several elements, especially the existing record of the district with particular regard to past production; prospective power consumption, both in mining and in metallurgical and chemical treatment of new or uncommon minerals; distance from the dam; and existing transportation routes. Detailed studies were made only in a few districts, notably the magnesite area of Muddy Mountains, the borate area near Kramer, and the celestite deposits near Ludlow. Altogether nearly 200 districts were visited.

The range and number of minerals that might assume commercial importance in the area and deserve examination and record in this summary also presented a problem. In this region there are numerous mineral deposits, such as those of gold, silver, copper, lead, zinc, and borates, that have been exploited with profit over a long period and that deserve serious consideration as sources in the future. Another group includes those deposits of common or uncommon minerals that are either unusually large or exceptionally pure for which an obvious market does not yet exist. The attempt has been made to examine the outstanding deposits and to include most of them in this summary. The deposits of magnesite and brucite may be regarded as typical of these. Still another group includes those minerals which are known rather widely in small quantity but which rarely are found in concentrated or pure form. For these, a good price may be offered at points of consumption, but the merit of any deposit depends upon its extent or purity. Some of these minerals, such as niter and asbestos, are known to occur widely in this area, but the existing record has not held out enough promise to warrant field examination.

Obviously, an investigation of this kind, involving several varieties of field work that ranged from rapid reconnaissance of a few mines in large important districts, for which much information was already available, to very detailed examinations of resources not hitherto examined or explored, raises problems concerning the character of the report that should be issued. It is widely believed that the mineral resources will soon create a market for considerable power from Boulder Dam and that an exhaustive compilation and appraisal of the recorded mineral resources will contribute to this end. On the other hand, where detailed studies have been made, many of the details may bear upon plans or processes of exploration in the near future. The conclusion has been reached that this report should contain all the geologic data gained during the field work that may facilitate plans for exploitation of the resources, particularly of certain borate and magnesite deposits.

With this text are submitted three maps. Sheet I shows the location of the nonferrous-metal districts, the metals produced, and, by symbols, the general character of the deposits and the approximate value of the production since 1902. For districts whose production before 1902 is on record, a summary statement appears in the text. The time available and the complicated nature of the problem did not permit more than a general estimate of the reserve situation, but it is well recognized that past production of metal-mining districts is an important factor in appraising future prospects.

Sheet II shows the location of the ferrous-metal districts and indicates by symbol past production and general character of reserves. Sheet III shows the same information for the nonmetallic deposits. It should be noted that not every recorded occurrence of the minerals is shown. The districts or mines that appear on the maps are those which, in the judgment of the geologists who have done the field work, appear to be most worthy of consideration as markets for power or as sources of raw materials for local industries.

Throughout this report the symbol ● indicates that the district was examined during this inquiry or recently.

Summary.—This inquiry indicates that the region under consideration contains an uncommonly wide range of commercially valuable minerals and that some are present in great quantity of good grades and in part readily accessible by truck or railroad transportation to the area near the dam.

An appraisal of the resources may be expressed as follows:

A. Minerals or ores that have been found to be present in large quantity, of good or excellent quality, and readily accessible to transportation:

1. Nonferrous-metal ores: Lead-zinc or lead and zinc, Pioche, Yellow Pine (Goodsprings), Comet, Nev., and Wallapai, Ariz.; Copper, Jerome, Ariz.

2. Ferrous-metal ores: Iron, Iron Springs (Desert Mound), Utah, and Baxter (Cave Canyon), Calif.; tungsten, Atolia, Calif., and Boriana, Ariz.

3. Nonmetallic minerals: Limestone, dolomite, gypsum, borates, celestite, salines (sodium chloride, sodium sulphate, sodium carbonate, potassium bromide, potassium chloride, calcium chloride), bleaching clays, refractory silica, and alunite.

B. Minerals or metals which have been found to be present in large quantity near a railroad but of a grade below that commonly considered acceptable and which may require new or uncommon methods of treatment before they can be marketed.

1. Nonferrous-metal ores: None.

2. Ferrous-metal ores: Manganese, Las Vegas (Three Kids), Nev.

3. Nonmetallic minerals: Magnesite, Muddy Mountains, Nev.; coal, Colob-Kanab field, Utah.

C. Minerals or metals which have been found to be present in large quantity and of good or excellent quality but which are remote from railroads that would insure cheap transportation to the dam area:

1. Nonferrous-metal ores: Eureka district, Arizona.

2. Ferrous-metal ores: Iron, Eagle Mountains, Kingston Mountains, San Bernardino County, Calif.; manganese, Artillery Peak, Mohave County, Ariz.

3. Nonmetallic minerals: Magnesite and brucite, Paradise Range, Nye County, Nev.

There are many districts in this region that contain noteworthy deposits of metals and nonmetallic minerals, some of which have already yielded a large production but will probably not contribute raw materials to industries near the dam. Included in this group would be numerous mines and districts whose principal product is gold or silver. Some of these, or groups of them, may when operated become potential consumers of power transported by trunk lines from Boulder Dam, but on the whole it is believed that the number will be small. These districts or groups of districts will reveal themselves by careful study of all the factors that determine success in operating mines. It is believed that the chief hope for markets for Boulder Dam power arising out of mining activities will lie in manufacturing industries located near the dam and using nearby mineral raw materials.

METALLIFEROUS RESOURCES

NONFERROUS-METAL DEPOSITS

By T. B. Nolan

The nonferrous-metal deposits in the region tributary to the Boulder Dam are, for all practical purposes, those of gold, silver, copper, lead, and zinc. Small quantities of minerals containing other metals are known within the area but appear to be of little commercial importance, even with greatly improved power facilities.

In the following pages some brief notes are given on the mining districts within the Boulder Dam region that contain deposits of these five nonferrous metals. The location of the districts is shown on sheet I, which indicates also their production since 1902, the metals produced, and the major type of deposits found, and shows whether the district was examined for the present report. In the text an attempt has been made to indicate for each district the proximity of the deposits to railroad transportation, the geologic setting of the ores, the history of their exploration and their productivity, and the status of mining in the first half of 1934, when the field work was done. References to earlier reports on the districts are included. The production figures quoted for the districts in Arizona, Utah, and Nevada were obtained from records compiled by V. C. Heikes and C. N. Gerry for the United States Geological Survey until 1925 and for the United States Bureau of Mines since 1925; those for California are estimates made by the writer from sundry sources.

The figures represent recoverable metal. The values for the production are those computed by the United States Geological Survey and the Bureau of Mines on the basis of annual weighted average prices for the individual metals. For methods of calculation see prefatory notes to the reports on gold, silver, copper, lead, and zinc in the annual volumes of Mineral Resources of the United States, part 1—for example, pages A125–A127 in the report for 1926.

Considerable difficulty was experienced in determining just what should constitute a mining district for the purposes of this report. In many places two or more names have been applied to an area that is now generally considered to be a single district, and in others it was found that a name originally applied to a locality has in recent years either been lost sight of or used for an adjoining area. It was also found that there has been an extremely wide variation in the limits given to an individual district. Thus in one locality a single name will be applied to a large area enclosing widely separated deposits of diverse character, and in other localities individual names have been applied to areas near together with similar ore bodies.

A definition of an ideal mining district would require that it enclose an area of moderate size that is well defined, either geographically or geologically, and that contains a group of related ore deposits. Wherever it was possible, this was used as a basis for selecting a name, but in many places the district name here given represents a compromise between local usage, usage in previous reports, and what would be geologically preferable. The limits of districts in California were particularly difficult to determine, probably in large part because the production figures have been assembled by counties and not by districts, as in the other three States. The confusion as to the nature of a district has naturally resulted in inaccuracies in the statistical reports, so that some relatively minor errors may be found in the production figures quoted.

ACKNOWLEDGMENTS

The writer is indebted for many courtesies to the mine operators, geologists, and prospectors, too numerous to mention individually, who freely provided information and assistance during the course of the field work, which extended from February 26 to June 2, 1934. He also gratefully acknowledges the help received from J. A. Fulton, Director of the Nevada State Bureau of Mines, and G. W. Malone, State engineer of Nevada; E. D. Wilson and Director G. M. Butler, of the Arizona State Bureau of Mines; and officials of the Bureau of Reclamation at Boulder City.

C. N. Gerry and Miss Helen Gaylord, of the United States Bureau of Mines offices at Salt Lake and San Francisco respectively, made available the production records that constitute an important part of this report and generously provided office space and facilities during the time in which the records were being copied.

Messrs. D. F. Hewett and Eugene Callaghan, of the United States Geological Survey, and Kenneth Leith, of the National Resources

Board, provided unpublished information regarding some of the districts.

SUMMARY OF NONFERROUS-METAL RESOURCES

General features.—In the preliminary report upon the results of the survey[2] the nonferrous mining districts were grouped into three rather arbitrary classes for purposes of appraisal—precious-metal districts, copper districts, and lead-zinc or silver-lead-zinc districts. This classification has many advantages in a consideration of the possible future power consumption in or resulting from the development of individual mining districts; but before discussing the three groups, it is worth while to mention some general features that apply to the region as a whole.

The 284 districts shown on sheet I produced nonferrous metals valued at nearly $1,000,000,000 during the years 1902–32, an average for the whole region of about $30,000,000 annually. Five districts (Verde, Tonopah, Goldfield, Oatman, and Randsburg) have produced about 75 percent of this total; and five more (Yellow Pine, Pioche, Frisco, Big Bug, and Wallapai) have provided an additional 10 percent. These figures show clearly that the great bulk of the mining activity is concentrated at relatively few points and imply that large consumption of power in mining or milling will be localized in such centers of large production.

The well-known fact that mining is the exploitation of a wasting asset must be considered in any planning of future power consumption by the industry. Some of the districts described in the text have developed large reserves of ore, which assure the continuation of their operations for many years if favorable conditions exist. Many of the larger districts and nearly all the smaller ones, however, have essentially no proved reserves or thus far have developed material that can be mined profitably only during periods of unusually high prices for their products. Unless new deposits or additional extensions of old deposits are found, therefore, it is to be expected that there will be a gradually diminishing output from the region.

Very few discoveries of new ore bodies have been made in the last 20 years, and practically all of the new ore found during this period has come from the extensions of previously known ore bodies or from material made minable by technologic advances. The few outstanding discoveries, all of which have been in old districts, are the copper bonanza of the United Verde Extension, discovered in 1914; the silver bonanza of the Kelly-Rand mine, discovered in 1919; and some of the ore bodies in the vicinity of Pioche. The Silver Queen

[2] Mineral resources and possible industrial development in the region surrounding Boulder Dam, pp. 8–9, Bur. of Reclamation, November 1934.

ore body, at Mohave, may prove to be of this type also. The United Verde Extension mine, however, is already approaching exhaustion, according to published company reports, and the production from the Kelly-Rand deposit is only a small fraction of the output made during the years immediately after its discovery.

It is probable that the chief hope for the discovery of additional mining districts within the region depends on the development of new prospecting methods. A large proportion of the total area shown on sheet I lies within the Basin and Range geomorphic province—that part of the West in which the mountain ranges are separated by wide valleys filled with accumulations of gravel, sand, and clay. The time of formation of the valleys, in many places, is clearly later than the time at which the ore deposits in the surrounding mountains were formed; and as the valleys make up a large proportion of the surface, it is therefore possible that ore bodies may be concealed beneath their gravel filling. The immense area of these valleys and the lack of knowledge regarding the thickness of their contained sediments present an insuperable obstacle to successful prospecting beneath them at the present time and by present methods. Gradual exhaustion of known ore bodies, however, may well provide the incentive to consider the practicability of searching for ore in such regions; and any successful search will require the use of geologic concepts, based on exhaustive data regarding the regional relations of known ore bodies, and of new prospecting tools, such as improved geophysical instruments.

Statistically, at least, there appears to be a fair basis for the expectation that potential mining districts may be found in the valleys. The uncertainties resulting from the loose definition of a mining district being disregarded, there are approximately the same number of mining districts per unit of area in the portions of Arizona, California, and Nevada included on sheet I. Furthermore, there is a fair concordance in the number of districts in each State that fall in each of the five productivity groups shown graphically on the map. This suggests that in very large areas, all within the same geologic province, the mineralization may have been roughly equal in amount and in quantitative distribution. These observations apply to the known districts, which are limited to the mountain areas. If, however, the valleys have been formed later than most of the ore bodies and independently of the structural features that controlled their localization, then we may entertain the hypothesis that a similar distribution is not improbable in the concealed areas. There is at present no geologic basis for this suggestion, and it may be in some respects opposed by the geologic evidence now available. Its validity seems worthy of further testing, however, for upon it must be based any program to add to the decreasing known reserves of nonferrous metals in the Boulder Dam region.

In the summary statements for individual districts the following symbols are used: Au, gold; Ag, silver; Cu, copper; Pb, lead; Zn, zinc. The distances from a railroad are approximate.

Precious-metal districts.—The precious-metal districts are probably relatively unimportant potential consumers of power. Unlike those of other metals, their output needs no additional power-consuming treatment for refinement or for manufacture into finished products, and their sole use of power is in the mining and milling of the ores, a use that requires transmission of the power to the individual mines.

With the exception of the new discovery at the Silver Queen mine, in the Mojave district, California, none of these districts are known to have large proved reserves of commercial grade, and it is probable that most if not all of the larger districts have passed the peak of their production measured in quantities of the metals. (See figs. 1, 3, 10, 12, 15, 16, 23, 24, 26, 27, 28, 29, 32, and 33.) In many of these larger districts, as well as in most of the smaller gold and silver districts, demands for power are likely to be somewhat erratic, reflecting periodic and on the whole short-lived (6 months to a few years) campaigns of mining and milling, resulting from small new discoveries or favorable economic conditions. At the present time the prevailing prices for gold and silver have caused a moderate increase in the output of the precious-metal districts, in large part by making ore of material hitherto too low in grade to mine; and this condition can be expected to continue until increasing costs cut into the margin of profit that now exists.

Copper districts.—All the copper districts, with the exception of the Verde (Jerome) district and the questionable exception of the Planet and Eureka (Bagdad mine) districts, all in Arizona, appear to be marginal producers and therefore unlikely to become regular power consumers, especially in the light of the excess capacity now existing. The copper districts within the region illustrate clearly a trend that appears to characterize copper districts over the whole country—a strong tendency toward concentration of the production into a few large camps and the virtual closing down of the smaller properties. Although this may be due in part to exhaustion of the smaller districts, the trend has been so general that it seems to be the result of factors that are economic rather than geologic. Thus, some districts have been practically inactive since 1919 (figs. 2, 7), in spite of the high copper prices prevailing in the late 1920's, and others (figs. 5, 6, 11) have shown only a very small production since the general shut-down that affected copper districts in 1921. Only the Verde district, Arizona (fig. 13), has shown a consistently large output since that time, and it is reported to have large reserves. If the United Verde mine should initiate its proposed plan for extracting metals and compounds other than copper (see pp. 28–29), the district would become a large user of power.

An electrolytic refinery near Boulder Dam could conveniently treat Utah and Nevada copper, as well as that produced at Jerome, Ariz., but in view of the relatively small power consumption per pound of copper, the current saving should be weighed against the added cost of transportation and the capital loss at existing refineries.

Lead-zinc and silver-lead-zinc districts.—Districts producing lead-zinc and silver-lead-zinc ores are believed likely to provide the best market for power among the three types of mining districts here considered, because, in addition to the power used at the mines, there is a possible additional consumption in the electrolytic refining of the zinc ore that is produced. The Pioche and Comet districts, Nevada, appear to have large reserves of mixed sulphide ore, and it is probable that with improved metal prices the Yellow Pine district, Nevada, the Wallapai district, Arizona, and possibly others might yield considerable amounts of ore. A far greater outlet for power than the amount used in the mining and milling of these ores, however, would be provided by the erection of an electrolytic zinc refinery near Boulder Dam. Ore for such a plant could be supplied not only from the above-named districts, but also from the Bingham, Park City, and Tintic zinc-producing districts in Utah. The consumption of power per pound of metal is greater in zinc refining than in copper refining, and the economic practicability of the erection of a new plant near Boulder Dam is believed worthy of detailed study.

ARIZONA

COCONINO COUNTY

Attempts have been made to work the copper deposits found in many parts of Coconino County on several occasions, chiefly during periods of high copper prices. These operations have been successful only exceptionally, owing in large part to the high transportation costs and in part to the relatively small size of many of the deposits.

Francis.—5 to 10 miles from railroad at Anita. Disseminated copper ore, in part at least oxidized, in Paleozoic sediments. Yielded a rather regular small production from 1906 to 1920 and was again a small producer in 1926–30. No recent activity. The deposits were discovered prior to 1906, but their early production is unknown, though probably small. Recorded production, 1906–32, 10,234 tons of ore yielding 19.18 oz. Au, 3,930 oz. Ag, 630,092 lbs. Cu, 502 lbs. Pb, valued in all at $121,112.

Grand Canyon.[3]—15 miles from railroad at Grand Canyon station. Disseminated copper ore along fracture zones in Paleozoic sediments; small lodes in pre-Cambrian rocks. The deposits were known and worked prior to 1897, but there is no record of the output prior to 1904. Shipments from the district were made in 1904–8 and 1913–19 and probably in 1929. There has been no recent activity. Recorded production, 1904–32, 1,303 tons of ore yielding 39.46 oz. Au, 6,202 oz. Ag, 816,568 lbs. Cu, valued in all at $145,470.

Pine Springs.—37 miles north of railroad at Pica. Disseminated copper ore in Paleozoic sedimentary rocks. The only recorded production was made in 1929 and consisted of 183 tons of ore containing, in addition to copper, small amounts of gold and silver. It was valued at more than $5,000.

Pipe Springs.—140 miles from railroad at Marysvale, Utah. Copper ores in Mesozoic red beds. The only record of activity in this district consists of one small shipment, in 1929, of copper ore containing a little silver and valued at less than $1,000.

Warm Springs (*Jacobs Lake*)[4].—167 miles from railroad at Marysvale, Utah. Copper-bearing veins and runs in Carboniferous sedimentary rocks. The district was known prior to 1900, and many unsuccessful attempts were made to exploit the ores. The total production consists of a small output in 1903 and 1916 and a larger one in 1929, a total of 1,066 tons of ore yielding 9.00 oz. Au, 446 oz. Ag, 178,641 lbs. Cu, 1,000 lbs. Pb, valued in all at $32,385.

White Mesa.[5]—135 miles from railroad at Flagstaff. Oxidized copper ore disseminated in Mesozoic sandstone. Deposits were known prior to 1902 but were productive only in 1917 when 1,077 tons of ore was shipped that yielded 3,357 oz. Ag and 277,514 lbs. Cu, valued in all at $78,527.

MARICOPA COUNTY

Big Horn.[6]—15 to 30 miles from railroad at Aguila. This poorly defined district, which appears to extend from the Harquahala Mountains to the Gila Bend Mountains, appears to have first become active about 1914. The ores are valuable chiefly for gold and copper and are found in veins cutting metamorphosed rocks. Re-

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[3] Emmons, S. F., Copper in the Red Beds of the Colorado Plateau region: U. S. Geol. Survey Bull. 260, pp. 221–232, 1905.

[4] Jennings, E. P., The copper deposits of the Kaibab Plateau, Ariz.: Am. Inst. Min. Eng. Trans., vol. 34, pp. 839–841, 1903. Brinsmade, R. B., Copper in northern Arizona: Eng. and Min. Jour., vol. 84, p. 962, 1907.

[5] Lunt, H. F., Discussion of the copper deposits of the Kaibab Plateau, Ariz.: Am. Inst. Min. Eng. Trans., vol. 34, pp. 989–990, 1903. Hill, J. M., Copper deposits of the White Mesa district, Ariz.: U. S. Geol. Survey Bull. 540, pp. 159–163, 1914.

[6] Wilson, E. D., Arizona lode gold mines and gold mining: Arizona Bur. Mines Bull. 137, p. 163, 1934.

corded production 1919–25, 1,254 tons of ore yielding 588.20 oz. Au, 561 oz. Ag, 61,211 lbs. Cu, 5,709 lbs. Pb, valued in all at $22,611.

Blue Tank.—30 miles from railroad at Salome. A shipment of oxidized copper ore containing gold and silver and valued at less than $1,000 was made in 1929 from what was termed the "Blue Tank district." There appears to be no sharp distinction between this district and the Big Horn district.

Eagle Eye.—5 miles from railroad at Aguila. Several small lots of copper and gold ore were shipped from this district in 1911, 1913, and 1914. They were valued at less than $1,000. The district might well be considered a part of the Ellsworth district.

Ellsworth (*Harquahala*).—10 to 15 miles from railroad at Aguila. Copper and gold ore was shipped in small amounts from this district in 1929 and 1932. The total value of the shipments was less than $1,000. The ore is probably found in veins cutting the metamorphosed or intrusive rocks that make up the Harquahala Mountains. (See p. 31.)

Osburn.—20 miles from railroad at Aguila. Small shipments of gold and oxidized copper ore, valued at less than $1,000, were made in 1929 and 1932. The district might well be included in the Big Horn district.

San Domingo (*Hassayampa River, Bitter Creek*).[7]—Near railroad at Morristown. Chiefly gold placers, but some copper-gold-silver veins in the pre-Cambrian have been productive. The gold placers have been known for many years, but their greatest yield was made between 1870 and 1880. The yield prior to 1905 is unknown, but was possibly in the vicinity of $100,000. The production in 1905–32 included 187 tons of ore from lode mining in addition to the placer production and comprised 863.27 oz. Au, 501 oz. Ag, 21,003 lbs. Cu, valued in all at $21,279.

Sunset.—10 to 15 miles from railroad at Aguila. Veins valuable chiefly for gold but containing also some copper, lead, and silver. From the information available it would seem that the district might better be considered a part of the Ellsworth district. Recorded production, 1915–32, 747 tons of ore yielding 701.79 oz. Au, 220 oz. Ag, 36,505 lbs. Cu, 4,373 lbs. Pb, valued in all at $23,763.

● *Vulture.*[8]—14 to 25 miles from railroad at Wickenburg. The district comprises both the Vulture Mountains and the region to the

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[7] Wilson, E. D., Arizona gold placers and placering: Arizona Bur. Mines Bull. 135, pp. 66–67, 1933.

[8] Wilson, E. D., op. cit., Bull. 137, pp. 157–162; Bull. 135, pp. 65–66. Purington, C. W., The Vulture mine, Ariz.: Min. and Sci. Press, vol. 94, pp. 308–310, 1907. Defty, W. E., The Vulture mine, Ariz.: Eng. and Min. Jour., vol. 93, p. 1044, 1912. Hutchinson, W. S., The Vulture mine: Eng. and Min. Jour., vol. 111, pp. 298–302, 1921. Thompson, A. P., Finding the lost Vulture mine: Arizona Min. Jour., vol. 14, no. 13, pp. 9–11, 28–30, 1930.

southwest across the valley. The gold-bearing lodes are found in pre-Cambrian gneiss and schist. The old Vulture mine was discovered in 1863 and was extensively worked in the periods 1866–72 and 1879–88. The production of the district prior to 1908 has been estimated at $5,000,000 to $16,000,000, but the lower figure appears to be more nearly correct. The Vulture mine was again worked in 1908–17, producing nearly $2,000,000, and was intensively explored by drilling by the United Verde Extension Co. in 1930–31, but the results were disappointing, and recent work has been largely confined to the surface and to the cyanidation of old tailings. The Belmont-McNeil mine about 15 miles south of the Vulture, was explored and worked by the Tonopah Belmont Co. in 1924–30 and yielded about $800,000 in lead-copper-silver ore. This property was closed early in 1930, owing to exhaustion of the ore. At both this property and the Vulture there are many faults, which have greatly hindered exploration. Recorded production of the district, 1907–32, 317,695 tons of ore yielding 110,839.33 oz. Au, 204,803 oz. Ag, 802,051 lbs. Cu, 7,599,893 lbs. Pb, valued in all at $2,977,424 (fig. 1).

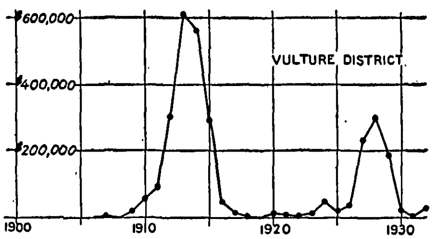

FIGURE 1.—Annual production of nonferrous metals in Vulture district, Arizona, 1907–32.

White Picacho.—This district, which is the extension of the district of the same name in Yavapai County,[9] is 8 to 15 miles from the railroad at Morristown. It has yielded several small lots of ore containing chiefly copper and lead from veins in pre-Cambrian rocks. Recorded production from the Maricopa County part of the district, 1907–32, 324 tons of ore yielding 49.05 oz. Au, 1,094 oz. Ag, 42,633 lbs. Cu, 81,352 lbs. Pb, valued in all at $14,582. (See p. 30.)

● *Wickenburg.*—Near railroad at Wickenburg. Placer gravel; lodes in pre-Cambrian rocks. Probably an extension of the Black Rock district, in Yavapai County.[10] Recorded production, 1905, 1907, 1914, and 1917, 723 tons of ore yielding 186.35 oz. Au, 1,240 oz. Ag, 52,669 lbs. Cu, 31,907 lbs. Pb, valued in all at $21,989.

MOHAVE COUNTY

Aubrey.—Location uncertain but believed to be about 10 miles southwest of Wikieup, in Big Sandy Valley, and 40 to 65 miles from the railroad at Yucca or Kingman. Ores valuable chiefly for gold are reported to be found in quartz veins cutting pre-Cambrian gneiss or schist. Recorded production, 1905–32, 156 tons of ore containing,

[9] Wilson, E. D., op. cit. (Bull. 137), pp. 65–66.
[10] Idem, pp. 62–65.

in addition to gold, small amounts of silver, copper, lead, and zinc, valued in all at $2,962. The production prior to 1905 is unknown but believed to be small.

Bentley.[11]—55 miles from railroad at St. Thomas, Nev. Replacement deposits of copper in sandy limestone along fissures or the borders of sink holes. The district was discovered about 1853 and was a small producer of copper for many years. Much of the ore was smelted at St. George, Utah. The production prior to 1902 was probably somewhat less than $500,000. The district yielded a rather steady production from 1906 to 1920 but has made only one small shipment since (in 1931). Recorded production, 1901–32, 18,916 tons of ore yielding 19.84 oz. Au, 27,991 oz. Ag, 7,923,839 lbs. Cu, 22,491 lbs. Zn, valued in all at $1,473,267 (fig. 2).

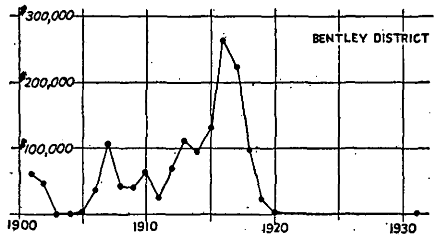

FIGURE 2.—Annual production of nonferrous metals in Bentley district, Arizona, 1901–32.

Buck Mountain.—About 10 miles from railroad at Haviland or Franconia. Silver-gold quartz veins in gneiss or schist. The only recorded production from the district was made in 1906 and consisted of 2 tons of ore containing gold and silver and valued at less than $1,000. The district might well be considered part of the Chemehuevis district.

Cedar Valley.[12]—5 to 20 miles from railroad at Yucca. A poorly defined district that appears to embrace the western slope of the Hualpai Mountains. Quartz veins in pre-Cambrian rocks. Probably was discovered in the seventies and worked for the enriched silver ores at the surface, producing about $100,000 prior to 1904. Has maintained a fairly steady though small production in recent years, the Boriana tungsten property being active in 1934. Recorded production, 1904–32, 15,728 tons of ore yielding 1,544.90 oz. Au, 48,428 oz. Ag, 322,426 lbs. Cu, 89,242 lbs. Pb, 2,372 lbs. Zn, valued in all at $128,269. (See p. 89.)

Chemehuevis.[13]—10 to 50 miles from railroad between Topock and Yucca. Placer gravel; gold quartz veins in pre-Cambrian rocks. The district is supposed to have been discovered many years ago, but there is no record of the production prior to 1909. There has been a steady small output in recent years. Recorded production, 1909–32, 394 tons of ore, in addition to bullion from placers, yielding

[11] Hill, J. M., The Grand Gulch mining region, Mohave County, Ariz.: U. S. Geol. Survey Bull. 580, pp. 39–57, 1915.

[12] Hamilton, Patrick, The resources of Arizona, 2d ed., p. 129, San Francisco, 1883.

[13] Wilson, E. D., op. cit. (Bull. 135), pp. 85–86; (Bull. 137), pp. 115–116.

together 613.72 oz. Au, 3,379 oz. Ag, 6,806 lbs. Pb, valued in all at $15,628.

Colorado River.[14]—Placer ground along the Colorado River from the mouth of the Grand Canyon downstream to Topock. Known and worked on a small scale for many years. The total output is unknown, the only recorded production being made in 1930 and valued at less than $1,000.

● *Cottonwood (Walkover).*[15]—9 miles from railroad at Hackberry. Gold-quartz veins in granitic gneiss and schist. The district appears to have been discovered more recently than those adjacent to it, the first record of it being made about 1907. Several efforts have been made to work the Walkover mine, which has yielded most of the ore from the district, but these appear to have been unsuccessful on the whole. Lessees were working the mine early in 1934. Recorded production, 1907–32, 6,241 tons of ore yielding 1,594.29 oz. Au, 4,055 oz. Ag, 259,353 lbs. Cu, 271 lbs. Pb, valued in all at $78,953.

● *El Dorado Pass.*[16]—20 miles from railroad at Boulder City, Nev. Quartz-hematite veins in pre-Cambrian gneiss. A small production of gold ore is reported from the district, but none has been recorded by Heikes and Gerry. The district was inactive early in 1934.

● *Gold Basin (Salt Springs).*[17]—40 miles from railroad at Hackberry. Gold-quartz veins and surficially enriched lodes in pre-Cambrian rocks; placer gravel. The district was discovered in the early seventies and is believed to have produced between $50,000 and $100,000 prior to 1904. It yielded a fairly regular small production up to 1920 but was then essentially inactive until 1932, since when there have been several efforts to work some of the old properties. Recorded production, 1904–32, 15,109 tons of ore yielding 6,244.91 oz. Au, 5,059 oz. Ag, 27 lbs. Cu, 1,765 lbs. Pb, valued in all at $133,014.

● *Gold Bug.*[18]—40 miles from railroad at Kingman. Gold-bearing quartz-specularite veins in pre-Cambrian gneiss and schist. The district was discovered in 1892 and is reported to have made a production of about $55,000 prior to 1896. Except for some development work in 1908, it appears to have been inactive from that time until 1931; there have since been some small-scale operations. The production of the district has probably been included with that of the Weaver district, to the south, by Heikes and Gerry, but appears to have been less than $5,000.

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[14] Wilson, E. D., op. cit., (Bull. 135), pp. 87–88.

[15] Idem (Bull. 137), p. 115.

[16] Schrader, F. C., Mineral deposits of the Cerbat Range, Black Mountains, and Grand Wash Cliffs, Mohave County, Ariz.: U. S. Geol. Survey Bull. 397, p. 218, 1909.

[17] Idem, pp. 118–127. Wilson, E. D., op. cit. (Bull. 137), pp. 76–78; (Bull. 135), pp. 82–83.

[18] Schrader, F. C., op. cit., pp. 217–218. Wilson, E. D., op. cit. (Bull. 137), p. 78.

Greenwood (*Signal*).—55 miles from railroad at Yucca or Hackberry. Gold quartz veins in pre-Cambrian gneiss and schist. The district has yielded a small output of gold for many years. Recorded production 1902–32, 1,394 tons of ore yielding 746.54 oz. Au, 769 oz. Ag, a few pounds of copper and lead, valued in all at $16,151. The production prior to 1902 is unknown.

● *Hackberry*.[19]—4 miles from railroad at Hackberry. Quartz veins in pre-Cambrian gneiss and schist. The district was known in the seventies and is reported to have produced $1,000,000 prior to 1904. A fair amount of silver-lead ore was mined in 1915–19, but there has been a negligible production since then. There was apparently no activity in the district early in 1934. Recorded production, 1907–32, 8,146 tons of ore yielding 2,153.27 oz. Au, 79,381 oz. Ag, 5,983 lbs. Cu, 156,498 lbs. Pb, 21,604 lbs. Zn, valued in all at $133,169.

● *Lost Basin*.[20]—75 miles from railroad at Kingman. Gold-copper veins in pre-Cambrian rocks; placer gravel. Lode mines were discovered in 1886 and have been sporadically prospected but have never been highly productive. Placers were first worked in 1931 and resulted in a minor boom, but the elaborate plant erected apparently was not successful, as it was inactive early in 1934. Recorded production, 1904–32, a few shipments of ore containing copper, gold, and silver, valued at less than $5,000.

● *Maynard*.[21]—5 to 20 miles from railroad at Kingman. Quartz veins in pre-Cambrian gneiss. The district was discovered in 1865, but little work was done until it was reorganized in 1871. The surficially enriched silver ores are reported to have yielded several hundred thousand dollars prior to 1904. Since that time there has been sporadic activity in the district, principally between 1919 and 1928. Early in 1934 two or three properties were working, but only one was yielding ore in any quantity. Recorded production, 1904–32, 3,982 tons of ore yielding 643.22 oz. Au, 90,093 oz. Ag, 3,149 lbs. Cu, 104,248 lbs. Pb, valued in all at $103,669.

McConnico.[22]—5 miles from railroad at McConnico. Gold quartz veins in pre-Cambrian rocks. Essentially inactive early in 1934. Some production is reported from the district, but none is recorded by Heikes and Gerry. Possibly the shipments have been included with those from the Maynard or Wallapai district.

● *Music Mountain*.[23]—25 miles from railroad at Hackberry. Thin gold quartz veins in granitic gneiss. The district was discovered in

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[19] Schrader, F. C., op. cit., p. 141. Hamilton, Patrick, The resources of Arizona, 2d ed., p. 128, San Francisco, 1883.

[20] Schrader, F. C., op. cit., pp. 150–151. Wilson, E. D., op. cit. (Bull. 137), pp. 75–76; (Bull. 135), pp. 83–84.

[21] Schrader, F. C., op. cit., pp. 139–142. Hamilton, Patrick, op. cit., pp. 127–128.

[22] Schrader, F. C., op. cit., pp. 135–138.

[23] Schrader, F. C., op. cit., pp. 142–150. Wilson, E. D., op. cit. (Bull. 137), pp. 108–109.

1880 and is reported to have produced more than $20,000 prior to 1904. There have been a few sporadic shipments since that time, the latest in 1931. Early in 1934 there was no activity. Recorded production, 1905–32, 775 tons of ore yielding 481.57 oz. Au, 1,054 oz. Ag, 500 lbs. Cu, 5,600 lbs. Pb, valued in all at $11,050.

Needles Peak.—5 miles from railroad at Topock. There is a recorded production of 5 tons of gold-copper ore valued at less than $1,000 from this district, but probably it might better be included with the Chemehuevis district.

● *Owens* (*McCracken*).[24]—40 miles from railroad at Yucca. Lead-silver veins in pre-Cambrian gneiss, but probably related to Tertiary volcanism. The district was discovered in 1874 and is reported to have produced about $1,000,000 in the succeeding few years. After a long period of inactivity, work was revived about 1919 and yielded over $750,000 in lead-silver ore in 1922–25. There was little or no activity in the district early in 1934. The bulk of the production has come from only one of the several veins of jasperoidal quartz that crop out in the region. Recorded production, 1908–32, 101,791 tons of ore yielding 440.80 oz. Au, 624,000 oz. Ag, 36,941 lbs. Cu, 4,521,358 lbs. Pb, valued in all at $832,972.

● *Painted Desert.*—5 miles from branch railroad at Boulder City, Nev. Recent prospecting in this district has disclosed pegmatites containing minor beryl, quartz-specularite veins containing copper in pre-Cambrian gneiss cut by basic dikes, and gold-bearing lodes. Early in 1934 some gold ore was being developed in a sheared basic dike, associated with barite and specularite. No production had been made.

● *Pilgrim.*[25]—20 miles from railroad at Kingman. Gold-bearing veins in Tertiary volcanic rocks. The district was discovered in 1903 or 1904 and is reported to have shipped about $1,200 in gold ore prior to 1907. It has been explored several times in recent years, and some work was being done early in 1934. The only recorded production was made in 1929 and consisted of 50 tons of gold ore, valued at less than $5,000.

● *San Francisco* (*Oatman, Vivian, Gold Road, Boundary Cone*)[26].—29 miles from railroad at Kingman. Gold-bearing veins and stringer lodes in Tertiary volcanic rocks. The district was discovered in 1863 or 1864 and was worked in a small way for a few years thereafter. The early production probably amounted to less than $500,000.

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[24] Hamilton, Patrick, op. cit., pp. 128–129. Bancroft, Howland, Reconnaissance of the ore deposits in northern Yuma County, Ariz.: U. S. Geol. Survey Bull. 451, pp. 123–126, 1911.

[25] Schrader, F. C., op. cit., p. 214. Wilson, E. D., op. cit. (Bull. 137), p. 79.

[26] Lausen, Carl, Geology and ore deposits of the Oatman and Katherine districts, Ariz.: Arizona Bur. Mines Bull. 131, 1931. Wilson, E. D., op. cit. (Bull. 137), pp. 80–100. Ransome, F. L., Geology of the Oatman gold district, Ariz.: U. S. Geol. Survey Bull. 743, 1923.

Mining was revived in the district in 1900, and the Gold Road mine became a large producer. The Tom Reed mine in 1910 and the United Eastern in 1917 both considerably increased the output of the district in the years following. The United Eastern mine was closed in 1924 with its ore bodies exhausted, and the production of the district since that time has come largely from lessees' operations and some company operations by the Tom Reed. Early in 1934 the Tom Reed and several lessees were producing ore, and it was reported that the Gold Road mine was to be reopened. It was believed locally that the prevailing price for gold would permit the mining of material previously of too low grade to be profitably worked, but the observations of Lausen as to the gold content of the different stages of the quartz found in the veins[27] would seem to indicate that this belief might not be justified. Recorded production, 1902–32, 2,767,114 tons of ore yielding 1,695,695.54 oz. Au, 919,899 oz. Ag, valued in all at $35,822,901 (fig. 3). These figures include the output of the Union Pass district prior to 1925.

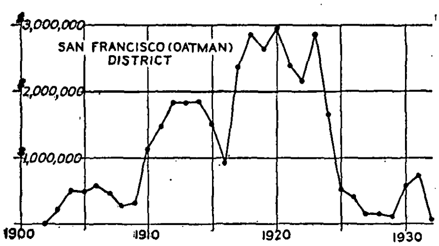

FIGURE 3.—Annual production of nonferrous metals in San Francisco (Oatman) district, Arizona, 1902–32.

● *Union Pass (Katherine)*.[28]—About 30 to 35 miles from railroad at Kingman. Gold-silver veins and lodes in pre-Cambrian granite and Tertiary volcanic rocks. The district was discovered in the late sixties and made a moderate early production. The Katherine deposit was discovered in 1900 and caused a small revival. Its main production was made in the period 1925–29, and it was closed as exhausted in 1930. Since that time other properties have been developed, and early in 1934 three or four mines were producing gold ore of rather low grade, which was milled at the Katherine plant. The production of the district prior to 1925 has been included in the output of the San Francisco (Oatman) district. Recorded production, 1925–32, 197,039 tons of ore yielding 49,218.12 oz. Au, 83,464 oz. Ag, valued in all at $1,065,373. The total output of the district has been estimated at $3,000,000.

● *Wallapai (Hualpai, Union Basin, Mineral Park, Cerbat, Stockton Hill, Chloride)*.[29]—10 to 20 miles from railroad at Kingman. Quartz sulphide veins in pre-Cambrian gneiss. Some of the deposits may

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[27] Lausen, Carl, op. cit., p. 72.

[28] Lausen, Carl, op. cit. Wilson, E. D., op. cit. (Bull. 137), pp. 101–108. Schrader, F. C., op. cit., pp. 203–214.

[29] Schrader, F. C., op. cit., pp. 49–118. Wilson, E. D., op. cit. (Bull. 137), pp. 109–115. Bastin, E. S., Origin of certain rich silver ores near Chloride and Kingman, Ariz.: U. S. Geol. Survey Bull. 750, pp. 17–39, 1925. Hamilton, Patrick, op. cit., pp. 126–127.

have been discovered in the sixties, but the bulk of the prospecting started about 1872. The rich silver ores found near the surface yielded a large production in the next few years, but the base-metal ores found below water level apparently were not extensively mined until the completion of the branch railroad from Kingman to Chloride, in 1899. This railroad has recently been dismantled. A moderate quantity of lead-zinc ore was mined from 1900 until 1918, reaching its peak in the war years, 1915–18, when 17,000,000 pounds of zinc and 6,000,000 pounds of lead were produced annually. The production declined rather abruptly after 1918, and early in 1934 most of the work in the district was confined to rather small-scale operations on veins with a relatively high gold content. The district contains a very large number of veins, and it is possible that with an increased price for base metals and a nearby treatment plant prospecting would show additional fair-sized bodies of mixed sulphide ores. Recorded production, 1904–32, 548,035 tons of ore yielding 58,016.27 oz. Au, 2,296,543 oz. Ag, 1,260,611 lbs. Cu, 39,063,067 lbs. Pb, 95,604,614 lbs. Zn, valued in all at $13,955,473 (fig. 4). The production prior to 1904 is unknown but was possibly about $10,000,000.

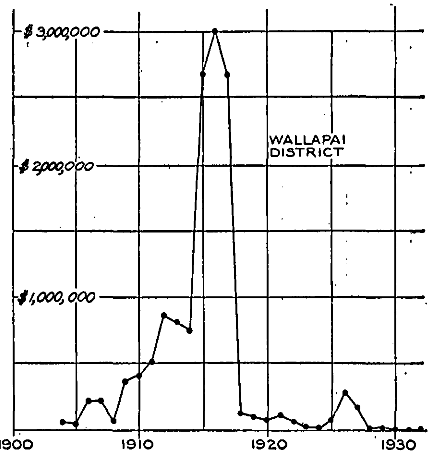

FIGURE 4.—Annual production of nonferrous metals in Wallapai district, Arizona, 1904–32.

Weaver (*Virginia, Mocking Bird*).[30]—40 to 45 miles from railroad at Kingman. Gold-bearing veins and lodes, chiefly in Tertiary volcanic rocks, and a few in the pre-Cambrian. The district was discovered prior to 1907, but the early production was probably less than $50,000. Some of the properties have had recurrent periods of activity, but early in 1934 there was essentially no work going on. Recorded production, 1907–32, 5,118 tons of ore yielding 1,627.29 oz. Au, 3,207 oz. Ag, 6,888 lbs. Cu, 2,360 lbs. Pb, valued in all at $38,017.

White Hills (*Indian Secret*).[31]—50 miles from railroad at Kingman. Silver-bearing veins in pre-Cambrian gneiss and schist. The district was discovered in 1892 and yielded an immediate and rather large production from the very rich oxidized ore shoots. Essentially all the ore-bearing ground was bought by an English company in 1895,

[30] Schrader, F. C., op. cit., pp. 214–217. Wilson, E. D., op. cit., (Bull. 137), pp. 78–80.
[31] Schrader, F. C., op. cit., pp. 127–135.

but its operations were apparently unsuccessful, and the property lapsed to the original owners. The activity in recent years has consisted of small shipments by lessees. Recorded production, 1906–32, 306 tons of ore yielding 340.55 oz. Au, 60,402 oz. Ag, 2,538 lbs. Cu, 12,802 lbs. Pb, valued in all at $53,908. The production prior to 1906 is reported to be $3,000,000, but this may be somewhat high.

YAVAPAI COUNTY

Agua Fria (*Copper Mountain*).[32]—5 miles from railroad at Mayer. Lenticular copper replacement bodies in schist. The district was known many years ago and produced some oxidized copper ore. Mining was revived in 1915 and yielded a rather large amount of copper, chiefly from one mine, between 1916 and 1924 (fig. 5). There appears to have been little or no activity since 1929. Recorded production, 1907–32, 210,099 tons of ore yielding 2,056.79 oz. Au, 171,407 oz. Ag, 12,478,846 lbs. Cu, valued in all at $2,704,892. The production prior to 1907 is unknown but was probably relatively small.

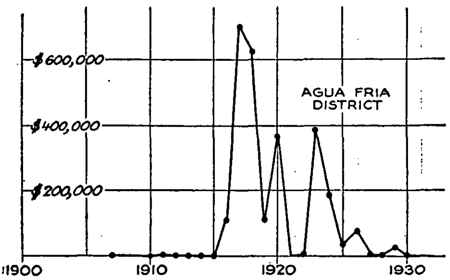

FIGURE 5.—Annual production of nonferrous metals in Agua Fria district, Arizona, 1907–32.

●*Big Bug* (*Chaparral*).[33]—1 to 5 miles from railroad at Mayer. Veins containing gold, silver, and lead and lenticular copper replacement bodies in schist. The district was probably discovered in the sixties and yielded considerable placer gold. The lode mines were exploited in the seventies and yielded gold and silver from oxidized and enriched ores; some of the mines were very productive. The base-metal ores, especially those containing copper, were not extensively mined until about 1900. Copper production reached its peak in 1918 and has been relatively small since 1927. The Blue Bell mine, which yielded the bulk of this type of ore, is reported to have been abandoned. Early in 1934 there was activity only in gold lode and placer mining, for the most part on a very small scale. Recorded production, 1902–32, 1,290,583 tons of ore yielding 180,057.73 oz. Au, 2,579,434 oz. Ag, 58,117,381 lbs. Cu, 6,425,895 lbs. Pb, 214,297 lbs. Zn, valued in all at $17,110,959 (fig. 6). The production prior to 1902 was probably about $5,000,000.

[32] Lindgren, Waldemar, Ore deposits of the Jerome and Bradshaw Mountains quadrangles, Ariz.: U. S. Geol. Survey Bull. 782, pp. 146–149, 1926.

[33] Idem, pp. 126–146. Hamilton, Patrick, op. cit., pp. 95, 102. Wilson, E. D., op. cit. (Bull. 135), pp. 44–48; (Bull. 137), pp. 35–41.

Black Canyon (Tip Top).[34]—10 to 30 miles from railroad at Mayer. Gold-quartz veins and pyritic lenses in pre-Cambrian schist; gold placers. The district has been known for many years, but the production prior to 1904 does not appear to have been great, possibly about $100,000. Since 1904 there has been a rather regular production amounting to a few thousand dollars a year. In 1931–34 several of the gold properties have been active. Recorded production, 1904–32, 16,133 tons of ore yielding 5,431.18 oz. Au, 101,096 oz. Ag, 27,340 lbs. Cu, 185,611 lbs. Pb, 12,910 lbs. Zn, valued in all at $196,383.

Black Hills (Ash Creek, Dewey).[35]—5 or 10 miles from railroad at Yaeger or Dewey. Veins containing copper and other metals in pre-Cambrian rocks. The bulk of the production from this district was made prior to 1908 from ore containing copper, silver, and some gold. In recent years the annual production has averaged less than $5,000. Recorded production, 1904–32, 17,898 tons of ore yielding 228.34 oz. Au, 60,164 oz. Ag, 1,534,228 lbs. Cu, 33,213 lbs. Pb, valued in all at $252,390. The production prior to 1904 probably approached $1,000,000.

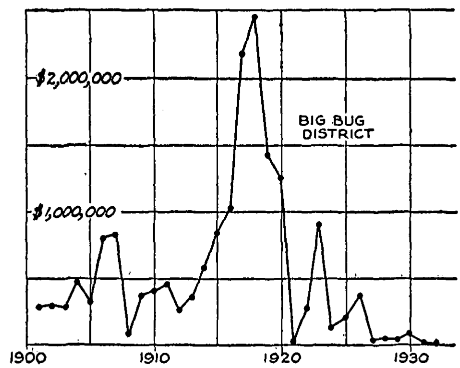

FIGURE 6.—Annual production of nonferrous metals in Big Bug district, Arizona, 1901–32.

Black Rock.[36]—5 to 15 miles from railroad at Wickenburg. Veins in pre-Cambrian rocks containing gold, copper, silver, and lead. One property has a small shoot of native silver ore containing arsenides of cobalt and nickel. The district was worked in the seventies and probably yielded about $100,000 prior to 1904. Nearly $200,000 was produced from 1904 through 1908, and since that time there has been a rather regular small annual output. Early in 1934 several of the properties were being worked, mostly on a small scale. Recorded production, 1904–32, 30,225 tons of ore yielding 9,451.47 oz. Au, 51,732 oz. Ag, 175,235 lbs. Cu, 133,921 lbs. Pb, valued in all at $261,167.

Blue Tank.—2 to 10 miles from railroad at Wickenburg. Copper ores containing gold and silver in pre-Cambrian rocks. Small ship-

[34] Lindgren, Waldemar, op. cit., pp. 152–160. Wilson, E. D., op. cit. (Bull. 137), pp. 51–55; (Bull. 135), pp. 51–52.

[35] Lindgren, Waldemar, op. cit., pp. 97–102.

[36] Bastin, E. S., Primary native silver ores near Wickenburg, Ariz., and their bearing on the genesis of the silver ores of Cobalt, Ontario: U. S. Geol. Survey Bull. 735, pp. 131–155, 1923. Wilson, E. D., op. cit. (Bul. 137), pp. 62–65.

ments have been made on several occasions from this district, which might well be included in either the Black Rock or the White Picacho district. Total output, 1904–32, 185 tons of ore, valued at somewhat more than $5,000.

Bradshaw.[37]—10 miles from railroad at Middleton. Gold and silver-bearing veins in granite. Deposits were known in the eighties and are reported to have made a moderate production. There is no recorded production since 1904, but it is possible that some output may have been included in the figures for adjoining districts.

Castle Creek.[38]—25 to 35 miles from railroad at Wickenburg or Hot Springs Junction. Veins containing chiefly gold and copper in pre-Cambrian rocks. The district was known prior to 1880, and several of the mines were productive prior to 1904; the value of the output was estimated at somewhat less than $500,000. There has been a small sporadic production since 1904, and early in 1934 there was some minor activity in the district. Recorded production, 1904–32, 682 tons of ore yielding 581.76 oz. Au, 885 oz. Ag, 60,610 lbs. Cu, 4,342 lbs. Pb, valued in all at $25,533.

Cherry Creek.[39]—16 miles from railroad at Dewey. Pockets of gold ore in quartz veins in pre-Cambrian granite. The district was discovered prior to 1882 and probably produced $50,000 to $100,000 by 1904. There was a fairly well sustained small output from 1907 to 1912; since that time the yield has been small. There was some activity early in 1934. Recorded production, 1904–32, 4,144 tons of ore yielding 2,271.44 oz. Au, 3,404 oz. Ag, 14,943 lbs. Cu, 3,058 lbs. Pb, valued in all at $51,595.

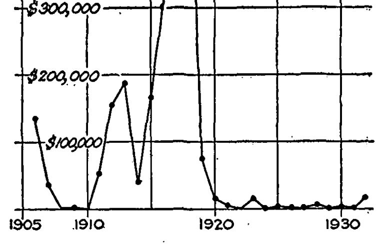

FIGURE 7.—Annual production of nonferrous metals in Copper Basin district, Arizona, 1906–32.

● *Copper Basin.*[40]—5 miles from railroad at Skull Valley. Disseminated copper ore in gravel and in granitic rocks; gold placers. The placers have been worked for more than 50 years, but the copper deposits were probably not extensively exploited until about 1900. They yielded a considerable amount of ore from 1911 to 1919 but have been inactive since that time. In recent years the placers have been

[37] Lindgren, Waldemar, op. cit., p. 176.

[38] Idem, pp. 182–187. Wilson, E. D., op. cit. (Bull. 137), pp. 61–62.

[39] Lindgren, Waldemar, op. cit., pp. 102–107. Wilson, E. D., op. cit. (Bull. 137), pp. 28–32. Reid, J. A., A sketch of the geology and ore deposits of the Cherry Creek district, Ariz.: Econ. Geology, vol. 1, pp. 417–436, 1906. Hamilton, Patrick, op. cit., pp. 100–101.

[40] Wilson, E. D., op. cit. (Bull. 135), pp. 41–44. Blake, W. P., The copper deposits of Copper Basin, Ariz., and their origin; Am. Inst. Min. Eng. Trans., vol. 17, pp. 479–485, 1889.

active, but the operations that were on a fairly large scale do not appear to have been successful. In 1934 a moderate amount of small-scale work was going on, the yield per man being from 50 cents to $1 a day. There was also some minor activity at gold lode mines. Recorded production, 1906–32, 115,477 tons of ore yielding 1,480.29 oz. Au, 46,721 oz. Ag, 9,734,227 lbs. Cu, 162,264 lbs. Pb, 38,352 lbs. Zn, valued in all at $2,197,339 (fig. 7). The production prior to 1906 is unknown but probably was less than $1,000,000.

Del Rio.[41]—On railroad. Gold placer deposits. A little placer gold has been recovered here, but there is no record of the amount or time of production. Possibly the output in recent years has been included with that of the Granite Creek district.

Deserted Hills.—North of railroad at Divide. There appears to be no information available about the exact location or nature of this district, from which only one shipment of 26 tons of ore has been recorded. This contained gold, with some silver and copper, and was valued at less than $1,000.

● *Eureka.*[42]—10 to 30 miles from railroad at Hillside. Veins and disseminated deposits in metamorphic and intrusive rocks. The district was probably discovered in the eighties and some of the properties, especially the Hillside, yielded considerable ore. The bulk of the output up to 1917 consisted of oxidized gold and silver ore from veins. In 1917–20 and 1925–27 the Copper King mine produced several million pounds of zinc, and in 1926–30 the Bagdad copper mine was prospected and had just started production when the price of copper started to drop. The Bagdad mine has been extensively explored and is reported to have developed 46,000,000 tons of ore containing 1.15 percent of copper, but apparently it cannot be worked profitably at the present time. Additional zinc ore is also reported to be present in the Copper King mine. Early in 1934 the activity in the district was confined to properties yielding gold and silver ores, principally the Hillside mine. Recorded production, 1904–32, 63,257 tons of ore, yielding 8,771.60 oz. Au, 65,881 oz. Ag, 689,702 lbs. Cu, 640,803 lbs. Pb, 8,228,930 lbs. Zn, valued in all at

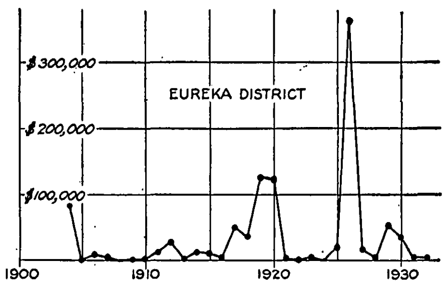

FIGURE 8.—Annual production of nonferrous metals in Eureka district, Arizona, 1904–32.

[41] Lindgren, Waldemar, op. cit., p. 54.

[42] Wilson, E. D., op. cit. (Bull. 137), pp. 23–28. Young, G. J., Another porphyry copper in the making: Eng. and Min. Jour., vol. 130, pp. 522–524, 1930. Storms, W. H., Arizona's new bonanza: Eng. and Min. Jour., vol. 50, pp. 162–163, 1890.

$1,014,507 (fig. 8). The production prior to 1904 probably amounted to several hundred thousand dollars.

Granite Creek.[43]—Along railroad north and south of Prescott. Chiefly placer gold with some lode gold. Placers were discovered and worked extensively in the eighties. There has been only a sporadic small production in recent years. Recorded production, 1904–32, 140 tons of ore together with placer bullion yielding 294.83 oz. Au, 384 oz. Ag, 4,251 lbs. Cu, valued in all at $6,833. The production prior to 1904 may have amounted to $100,000.

Hassayampa (Groom Creek).[44]—5 to 10 miles from railroad at Prescott. Veins in pre-Cambrian rocks; gold placers. Placers were discovered in 1863 and reached their greatest production in the eighties. The lode deposits were discovered shortly after the placers and yielded a considerable amount of gold and silver from oxidized ores. The sulphide ores were first worked in 1895. Since 1904 there has been a fairly regular moderate production, with the greatest value in gold. Several of the properties were active in 1934. Recorded production, 1904–32, 68,770 tons of ore yielding 23,246.82 oz. Au, 361,436 oz. Ag, 1,675,484 lbs. Cu, 1,750,369 lbs. Pb, 538,466 lbs. Zn, valued in all at $1,115,797 (fig. 9). The production prior to 1904 may have been as much as $5,000,000.

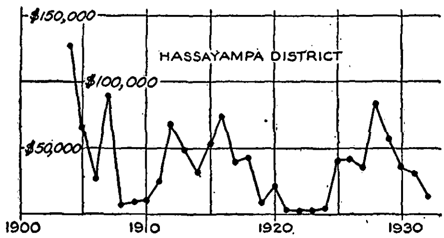

FIGURE 9.—Annual production of nonferrous metals in Hassayampa district, Arizona, 1904–32.

Humbug.[45]—35 miles from railroad at Morristown. Gold-bearing veins in pre-Cambrian rocks. The district was discovered about 1880; the early activity was largely confined to the placers. The early production is unknown but probably was not large. Since 1904 the output has been rather sporadic, but in 1934 there was some activity on both lode and placer properties. Recorded production, 1904–32, 1,819 tons of ore yielding 893.76 oz. Au, 2,639 oz. Ag, 145,220 lbs. Cu, 64,209 lbs. Pb, valued in all at $54,034.

Lynx Creek (Prescott).[46]—5 miles from railroad at Prescott. Chiefly gold placers but some gold quartz lodes. Placers discovered in 1863 and reported to have produced more than $1,000,000 in the succeeding years. Several unsuccessful attempts to work the placers

[43] Wilson, E. D., op. cit. (Bull. 135), p. 52.

[44] Lindgren, Waldemar, op. cit., pp. 113–126. Wilson, E. D., op. cit. (Bull. 135), pp. 48–49; (Bull. 137), pp. 32–33, 41–50. Hamilton, Patrick, op. cit., pp. 96–97.

[45] Lindgren, Waldemar, op. cit., pp. 178–179. Wilson, E. D., op. cit. (Bull. 135), pp. 52–53; (Bull. 137), pp. 60–61.

[46] Lindgren, Waldemar, op. cit., pp. 107–109. Wilson, E. D., op. cit. (Bull. 135), pp. 33–38; (Bull. 137), p. 28. Hamilton, Patrick, op. cit., p. 93.

on a large scale have been made; in 1933, however, a dredge was operating. Recorded production, 1904–32, 408.09 ounces of placer gold and 58 ounces of silver, valued in all at $8,462. These figures are incomplete, however, as part of the placer output has been included in the figures for the Walker district.

● *Martinez* (*Congress*).[47]—3 miles from railroad at Congress Junction. Gold quartz veins in pre-Cambrian rocks. The district was discovered in 1870, but the production appears to have been small prior to the opening of the Congress mine. This deposit was discovered in 1887 but was not intensively worked until 1894. Company work at this mine stopped in 1910, and since that time the annual production of the district has been small (fig. 10). Early in 1934 some work was being done on the dumps, and it was reported that exploration work was planned in the mine. Recorded production, 1901–32, 544,851 tons of ore yielding 194,084.26 oz. Au, 277,228 oz. Ag, 26,265 lbs. Cu, 1,052 lbs. Pb, valued in all at $4,156,382. The production prior to 1901 was probably between $4,000,000 and $5,000,000.

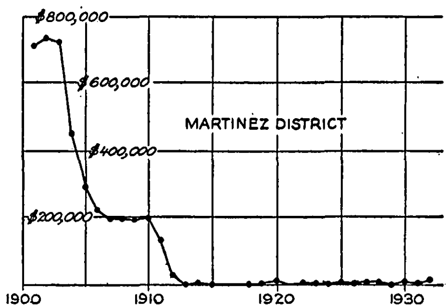

FIGURE 10.—Annual production of nonferrous metals in Martinez district, Arizona, 1901–32.

Minnehaha Flat (*Silver Mountain*).[48]—35 miles from railroad at Kirkland. Gold quartz veins in pre-Cambrian rocks; gold placers. The district was active in the eighties, when the placers were exploited. It has made a very small output in recent years, but early in 1934 there was still minor activity in the region. Recorded production, 1904–32, 112 tons containing chiefly gold, with some silver, copper, and lead, valued in all at less than $10,000. The production prior to 1904 was possibly about $200,000.

Ochocomo (*Santa Maria River*).—30 miles from railroad at Congress Junction. No information is at hand regarding the ore deposits of this district. One shipment of gold ore containing silver and copper, and one lot of gold bullion from placer operations are recorded for 1931 and 1932. The aggregate value of these shipments is less than $1,000.

Old Tip Top.[49]—35 miles from railroad at Middleton. Silver-rich quartz veins in pre-Cambrian rocks. The district was dis-

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[47] Wilson, E. D., op. cit. (Bull. 137), pp. 69–73. Staunton, W. F., Ore possibilities at the Congress mine: Eng. and Min. Jour., vol. 122, pp. 769–771, 1926.

[48] Lindgren, Waldemar, op. cit., pp. 176–178. Wilson, E. D., op. cit. (Bull. 135), p. 49; (Bull. 137), pp. 59–60.

[49] Lindgren, Waldemar, op. cit., pp. 179–182. Hamilton, Patrick, op. cit., pp. 91–92.

covered in 1875 and yielded bonanza ore from the Tip Top mine until 1883, when the mine was closed as exhausted. The mine was again worked in 1886–88 but appears to have been largely inactive since then. The only recorded production was made in 1901 and 1914, and consisted of 18 tons of silver ore, valued at $1,376. The production prior to 1901 was probably between $3,000,000 and $4,000,000.

Peck (*Ocotillo*).[50]—2 to 5 miles from railroad at Middleton. Silver-rich veins in pre-Cambrian rocks; lenticular copper bodies in schist. The district was discovered in 1875 and produced considerable amounts of oxidized silver ore from bodies near the surface in the next few years. The copper deposit of the De Soto mine appears to have first become productive about 1905 and has yielded a large part of the district's output since 1904, especially in 1906–7, 1915–20, and 1926–30; during the last period of activity it was operated by lessees. It would seem that the stimulus of a high copper price is necessary for operation of this mine. The silver mines have been also worked on several occasions since 1904.

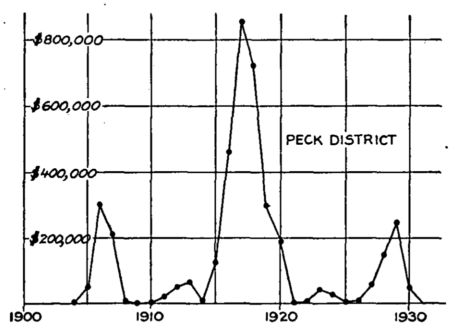

FIGURE 11.—Annual production of nonferrous metals in Peck district, Arizona, 1904–32.

Recorded production, 1904–32, 279,477 tons of ore yielding 16,145.14 oz. Au, 993,316 oz. Ag, 13,555,519 lbs. Cu, 264,146 lbs. Pb, valued in all at $3,979,156 (fig. 11). The production prior to 1904 was largely in silver and probably amounted to about $3,000,000.

Pierce (*Bullard*).—10 to 15 miles from railroad at Aguila. This district might well be considered the continuation of the Harcuvar district, in Yuma County. Copper veins containing gold and silver have yielded shipments amounting to 280 tons in 1919–20 and 1931–32, valued at $6,088.

Pine Grove.[51]—5 miles from railroad at Middleton. Veins in pre-Cambrian rocks. The district was probably discovered in the seventies and produced gold and silver from the oxidized and enriched surface ores. It has been revived several times since, once during the nineties and again in 1910–20, when base-metal ores were produced. Since 1920 the annual production has been small. Recorded production, 1904–32, 31,608 tons of ore yielding 4,890.66 oz. Au,

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[50] Lindgren, Waldemar, op. cit., pp. 160–164. Hamilton, Patrick, op. cit., pp. 90–91.

[51] Lindgren, Waldemar, op. cit., pp. 164–171. Wilson, E. D., op. cit. (Bull. 137), pp. 55–59. Hamilton, Patrick, op. cit., p. 98.

316,911 oz. Ag, 229,154 lbs. Cu, 67,306 lbs. Pb, 585,520 lbs. Zn, valued in all at $439,977. The production prior to 1904 was about $2,500,000.

Squaw Peak.—25 miles from railroad at Mayer. Little is known about this district, which Lindgren [52] notes as being 10 miles south of Camp Verde. There is no recorded production.

Thumb Butte.—The location and geology of this district which appears to be tributary to Prescott, are unknown to the writer. Shipments in several years since 1905 amounted to 2,004 tons of ore yielding 637.68 oz. Au, 9,857 oz. Ag, 3,776 lbs. Cu, 7,418 lbs. Pb, valued in all at $23,835.

Tiger (Harrington).[53]—8 to 10 miles from railroad at Middleton. Veins in pre-Cambrian rocks. The district was discovered in the seventies and yielded about $1,000,000 to $1,500,000 in gold and silver from the oxidized ores. Considerable activity prevailed from 1903 through 1916, especially in 1905–7, when a considerable tonnage of gold-silver ore was produced. The shipments since 1916 have been small, and since 1922 ore has been produced in only three years. Recorded production 1901–32, 118,565 tons of ore yielding 47,651.56 oz. Au, 316,904 oz. Ag, 437,549 lbs. Cu, 109,259 lbs. Pb, 726,348 lbs. Zn, valued in all at $1,365,068. The annual combined production of the Tiger and the adjoining Pine Grove district is shown in figure 12.

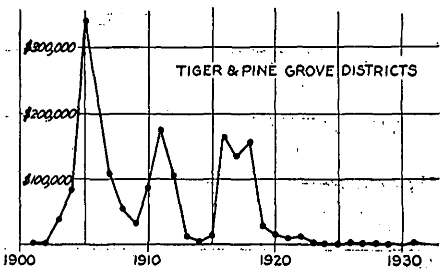

FIGURE 12.—Annual production of nonferrous metals in Tiger and Pine Grove districts, Arizona, 1901–32.

Turkey Creek (Bolada).[54]—10 to 15 miles from railroad at Mayer. Silver and gold-bearing veins in pre-Cambrian rocks. The district was discovered in the seventies and was the scene of a very rich silver strike about 1880. The oxidized and enriched silver ores probably yielded several hundred thousand dollars prior to 1900. From 1906 through 1928 there was a regular small output of rich silver ore, but since that time there appears to have been but little work done. Recorded production, 1906–32, 2,388 tons of ore yielding 808.52 oz. Au, 93,953 oz. Ag, 60,707 lbs. Cu, 67,412 lbs. Pb, valued in all at $106,127.

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[52] Lindgren, Waldemar, op. cit., p. 6.

[53] Idem, pp. 172–176. Wilson, E. D., op. cit. (Bull. 137), p. 59. Hamilton, Patrick, op. cit., pp. 97–98.

[54] Lindgren, Waldemar, op. cit., pp. 149–152. Wilson, E. D., op. cit. (Bull. 137), pp. 50–51. Hamilton, Patrick, op. cit., pp. 92–93.

● *Verde (Jerome).*[55]—On railroad. Lenticular and pipelike sulphide replacement bodies in pre-Cambrian rocks. The district was discovered in 1876, and some of the rich oxidized silver-copper ore was mined and smelted between 1880 and 1885. Owing to lack of transportation these operations were not generally successful. From 1889 on, however, the copper deposit of the United Verde mine has been extremely productive, as has also been since 1915 the enriched bonanza ore body of the United Verde Extension. The latter mine, according to the company's published reports, is now reported to be nearing exhaustion. There are large reserves of copper ore in the pyritic mass of the United Verde mine, but the company has not made public any exact figures. In 1922, however, it was reported that each 100 feet of development in depth along the ore body was required to maintain an annual production of 80,000,000 pounds of copper.[56] The present bottom level of the mine is the 3,000-foot level. The ore mined in the past has contained from 1 to 3 percent of zinc, but this has not been recovered. Plans have been made, however, to save the zinc, either in milling or by new smelting methods. In addition, there are bodies of higher-grade zinc ore that have not been fully explored. Ingalls[57] has reported 12,000,000 tons of 7 percent zinc ore in the mine, but other authorities believe that both tonnage and grade are somewhat too high.

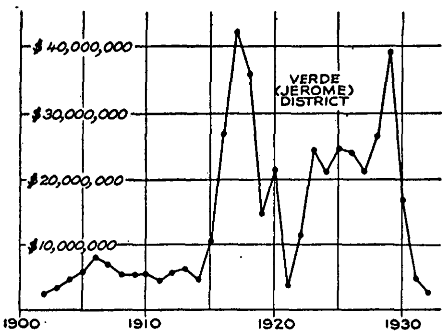

FIGURE 13.—Annual production of nonferrous metals in Verde (Jerome) district, Arizona, 1902–32.

Prior to 1934 the United Verde Co. had made plans to mine the entire sulphide mass, which is composed largely of pyrite, and, by pyrometallurgical methods, to recover, in addition to the copper, gold, and silver heretofore produced, zinc, iron, sulphur and sulphuric acid, selenium (which is present in relative abundance in the ores), and other byproducts.[58] It was reported that this project, if carried out,

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[55] Lindgren, Waldemar, op. cit., pp. 54–97. Reber, L. E., Jr., Geology and ore deposits of the Jerome district: Am. Inst. Min. Eng. Trans., vol. 66, pp. 3–26, 1922. Hansen, M. G., Geology and ore deposits of the United Verde mine: Min. Cong. Jour., vol. 16, pp. 306–311, 1930. Rickard, T. A., The story of the U. V. X. bonanza: Min. and Sci. Press, vol. 116, pp. 9–17, 47–52, 1918. Fearing, J. L., Jr., Some notes on the geology of the Jerome district, Ariz.: Econ. Geology, vol. 21, pp. 757–773, 1926.

[56] Smith, H. D., and Sirdevan, W. H., Mining methods and costs at the United Verde Mine: Am. Inst. Min. Eng. Trans., vol. 66, pp. 131–132, 1922.

[57] Ingalls, W. R., World survey of the zinc industry, pp. 63–64, New York, Min. and Met. Soc. America, 1931.

[58] Ralston, O. C., Fowler, M. G., and Kuzzell, C. R., Recovering zinc from copper smelter products: Eng. and Min. Jour., vol. 136, pp. 167–169, 1935.

would require 100,000 kilowatts delivered at a price of less than 4 mills per kilowatt-hour. The recent change in control of the United Verde Co., however, may cause these plans to be considerably modified. Recorded production of the district, 1902–32, 22,277,810 tons of ore yielding 1,000,070.08 oz. Au, 36,663,982 oz. Ag, 2,425,672,878 lbs. Cu, 213,779 lbs. Pb, valued in all at $442,515,327 (fig. 13). The production prior to 1902 may have been about $25,000,000.

Walker.[59]—5 to 10 miles from railroad at Prescott. Quartz veins in or near a granodiorite intrusion. The district was probably discovered in the late sixties and yielded an early production from surface ores. From 1905 to 1922 there was a fairly regular small output. In 1923–26 and 1929–30, however, the Sheldon mine yielded a considerable tonnage of gold-silver ore containing copper and lead. The production since 1930 has been very small (fig. 14). Recorded production, 1905–32, 134,149 tons of ore yielding 22,981.57 oz. Au, 571,234 oz. Ag, 4,128,771 lbs. Cu, 991,248 lbs. Pb, 72,415 lbs. Zn, valued in all at $1,499,684. The production prior to 1905 was probably close to $1,000,000.

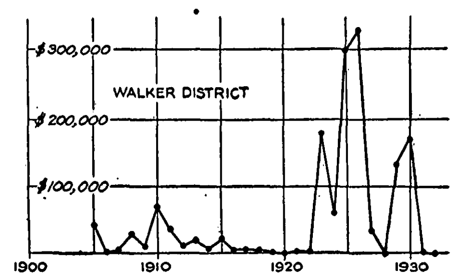

FIGURE 14.—Annual production of nonferrous metals in Walker district, Arizona, 1905–32.

Walnut Grove (*Kirkland*, *Wagoner*, *Oak Creek*).[60]—5 to 20 miles from railroad at Kirkland. Gold placers; veins in pre-Cambrian rocks. This poorly defined district appears to have been known since the seventies, but little information is available regarding its early output. There has been a fairly regular small production from both the placers and lodes in recent years, and the placer activity has been especially marked since about 1928. Recorded production, 1906–32, 1,323 tons of ore yielding, together with the placers, 668.67 oz. Au, 3,424 oz. Ag, 93,221 lbs. Cu, 77,596 lbs. Pb, valued in all at $36,869.

● *Weaver* (*Octave*, *Rich Hill*).[61]—10 miles from railroad at Congress Junction. Gold-quartz veins in pre-Cambrian rocks; gold placers. The placers were discovered in 1863 and yielded an early large production. Lode mining did not become important until the nineties, owing to the refractory nature of the ores. The Octave mine has been the chief lode mine of the district and yielded the greater part of its output between about 1899 and 1908. Several attempts

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[59] Lindgren, Waldemar, op. cit., pp. 109–113. Wilson, E. D., op. cit. (Bull. 137), pp. 34–35.

[60] Wilson, E. D., op. cit. (Bull. 135), pp. 49–50. Hamilton, Patrick, op. cit., p. 101.

[61] Wilson, E. D., op. cit. (Bull. 135), pp. 38–41; (Bull. 137), pp. 66–68. Hamilton, Patrick, op. cit., pp. 95–96. Nevius, J. N., Resuscitation of the Octave gold mine: Min. and Sci. Press, vol. 123, pp. 122–124, 1921.

have been made to work it since that time, and early in 1934 it was under option to the American Smelting & Refining Co. The placers have yielded a small annual production for several years. Recorded production, 1901–32, 209,166 tons of ore yielding 75,430.89 oz. Au, 44,468 oz. Ag, 22,298 lbs. Cu, 268,490 lbs. Pb, valued in all at $1,602,863 (fig. 15). The production prior to 1901 was probably about $2,000,000.

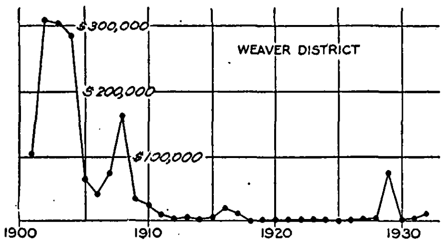

FIGURE 15.—Annual production of nonferrous metals in Weaver district, Arizona, 1901–32.

White Picacho.[62]—This district, which is a continuation of the similarly named district in Maricopa County, is 10 miles from the railroad at Morristown. The veins occur both in surface volcanic rocks and in the pre-Cambrian rocks. There have been several sporadic small shipments from the Yavapai County part of the district, and some leasing was going on early in 1934. Recorded production, 1905–32, 1,726 tons of ore yielding 310.96 oz. Au, 8,519 oz. Ag, 6,799 lbs. Cu, 68,063 lbs. Pb, valued in all at $16,801. (See p. 13.)

YUMA COUNTY

● *Castle Dome.*[63]—30 miles from railroad at Dome. Silver-lead fluorite veins in igneous and sedimentary rocks, gold-quartz veins, and gold placers. Ancient workings were found in 1863, when the district was organized. A fairly large production was made prior to 1890, in spite of transportation difficulties. Since then there has been a regular rather small output. The gold placers were discovered in 1884 and have made a total production of about $100,000; the gold veins have been worked since about 1912. Recorded production, 1904–32, 28,313 tons of ore yielding 2,296.85 oz. Au, 99,227 oz. Ag, 15,776 lbs. Cu, 4,570,981 lbs. Pb, valued in all at $390,008. The production prior to 1904 is believed to have been between $750,000 and $1,000,000. Hamilton, however, reports a production of $2,000,000 prior to 1883. (See pp. 88, 171.)

● *Cienega* (*Seneca*).[64]—5 to 15 miles from railroad at Parker. Gold-copper-hematite lodes in altered sediments and igneous rocks. The deposits have been known for many years but produced little

[62] Wilson, E. D., op. cit. (Bull. 137), pp. 65–66.

[63] Wilson, E. D., Geology and mineral deposits of southern Yuma County, Ariz.: Arizona Bur. Mines Bull. 134, pp. 77–105, 1933; op. cit. (Bull. 135), p. 22; (Bull. 137), pp. 148–149. Nevius, J. N., The Castle Dome lead district, Ariz.: Min. and Sci. Press, vol. 104, pp. 854–855, 1912. Hamilton, Patrick, op. cit., pp. 135–136.

[64] Wilson, E. D., op. cit. (Bull. 137), pp. 126–127. Bancroft, Howland, Reconnaissance of the ore deposits in northern Yuma County, Ariz.: U. S. Geol. Survey Bull. 451, pp. 73–78, 1911.

prior to the completion of the railroad to Parker, in 1908. Since that time there has been a fairly regular annual production, though the bulk of the output was made in 1916–18. There was some minor activity early in 1934. Recorded production, 1908–32, 7,469 tons of ore yielding 4,246.88 oz. Au, 3,701 oz. Ag, 1,082,421 lbs. Cu, 1,027 lbs. Pb, valued in all at $336,706. The production prior to 1908 has been estimated at $80,000, chiefly in gold.

●*Ehrenberg.*—10 miles from railroad at Blythe, Calif. Placer gold valued at less than $5,000 is reported to have been produced in 1909 and 1911. This district is probably essentially synonymous with the La Paz district.

●*Ellsworth (Harquahala).*[65]—5 to 15 miles from railroad at Salome. Gold lodes in altered sedimentary rocks. The district was discovered in 1888, although a little placering had been done 2 years previously. The ores near the surface of the Harquahala mine, the principal producer, were rich and yielded a considerable amount of gold prior to 1897, when the mine was considered exhausted. Since that time, however, there has been a fairly regular moderate output from the district, in large part from the Harquahala mine, and some work was being done early in 1934. Recorded production, 1904–32, 78,443 tons of ore yielding 13,889.41 oz. Au, 17,505 oz. Ag, 1,702,254 lbs. Cu, 156,663 lbs. Pb, valued in all at $666,660. This figure apparently includes the output of the Harcuvar district. The production prior to 1904 has been estimated at $2,500,000 to $3,500,000. (See p. 12.)

Harcuvar.[66]—5 to 15 miles from railroad at Vicksburg, Salome, and Wenden. Veins and lodes in altered sedimentary rocks. This district, which is an extension of the Pierce or Bullard district, in Yavapai County, appears to be regarded in the statistical reports as a part of the Ellsworth district. The copper-gold veins and lodes have been rather extensively prospected and have yielded a moderate amount of ore. The only recorded shipment was made in 1925 and was valued at less than $1,000, but it is probable that the actual production is in the neighborhood of $100,000.

●*Kofa (Humbug, Polaris).*[67]—35 miles from railroad at Growler. Chiefly gold-bearing lodes in Tertiary volcanic and older sedimentary rocks. The district was discovered in 1896 and yielded a considerable amount of ore from two mines until 1911. Since that time there has

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[65] Bancroft, Howland, op. cit., pp. 104–115. Wilson, E. D., op. cit. (Bull. 135), p. 32; (Bull. 137), pp. 128–134.

[66] Bancroft, Howland, op. cit., pp. 95–103, 115–120.

[67] Jones, E. L., Jr., A reconnaissance in the Kofa Mountains, Ariz.: U. S. Geol. Survey Bull. 620, pp. 151–164, 1915. Wilson, E. D., op. cit. (Bull. 134), pp. 106–122; (Bull. 135), pp. 22–23; (Bull. 137), pp. 136–143.

been only a negligible production. Early in 1934 some prospecting was going on in ground adjacent to one of the large producers. Recorded production, 1902–34, 563,502 tons of ore yielding 162,009.49 oz. Au, 71,364 oz. Ag, 5,028 lbs. Cu, 6,398 lbs. Pb, valued in all at $3,389,591 (fig. 16). This includes the output of the Sheeptanks district. The production prior to 1902 approached $1,500,000.

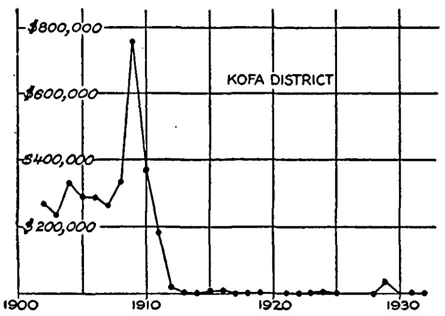

FIGURE 16.—Annual production of nonferrous metals in Kofa district, Arizona, 1902–32.

● *La Paz* (*Weaver*).[68]—10 to 15 miles from railroad at Blythe, Calif. Chiefly gold placers; some gold-bearing lodes in metamorphic and intrusive rocks. The placer deposits were discovered in 1862 and were remarkably rich, yielding a large production in the succeeding few years. With the exhaustion of the rich deposits the output dropped, but there have been a number of attempts since to work the lower-grade material on a large scale. None of these appear to have been successful. Early in 1934 there was some activity in both the lode and placer deposits. Recorded production, 1904–32, placer bullion valued at slightly less than $5,000, but it is believed that a large part of the district output has been included with that of the Plomosa district. The production prior to 1904 probably amounted to several million dollars, of which less than $100,000 came from the lode deposits.

● *Planet* (*Swansea*).[69]—Railroad at Swansea. Copper replacement deposits with specularite in folded and metamorphosed sediments. The deposits were known in 1862 and are reported to have made a small early production. The district revived in 1909, with the completion of the railroad to Parker. The original operation of the Swansea property, which contemplated local smelting, appears to have been unprofitable, but a fairly large output of ore was maintained from the property by the Swansea Lease, Inc., through 1924. The American Smelting & Refining Co. acquired a 12-year lease on the property in 1929 and constructed a 250-ton mill, which operated only a short time before closing in July 1930. Some development work was being done early in 1934, but there was no output. Reserves of 250,000 tons of 3 percent copper ore are reported in the

[68] Wilson, E. D., op. cit. (Bull. 135), pp. 24–31; (Bull. 137), pp. 135–136. Bancroft, Howland, op. cit., pp. 78–86. Jones, E. L., Jr., Gold deposits near Quartzsite, Ariz.: U. S. Geol. Survey Bull. 620, pp. 45–57, 1915.

[69] Bancroft, Howland op. cit., pp. 47–59. Higgins, Edwin, Copper deposits of northern Yuma County, Ariz.: Min. World, vol. 33, pp. 855–857, 903–904, 949–951, 1910.

Swansea mine, and the mill tailings, composed almost entirely of specularite, are thought to be a potential iron ore. Recorded production, 1909–32, 397,221 tons of ore yielding 1,066.94 oz. Au, 33,227 oz. Ag, 28,110,300 lbs. Cu, 779 lbs. Pb, valued in all at $5,292,596 (fig. 17). The production prior to 1909 was small. (See p. 84.)

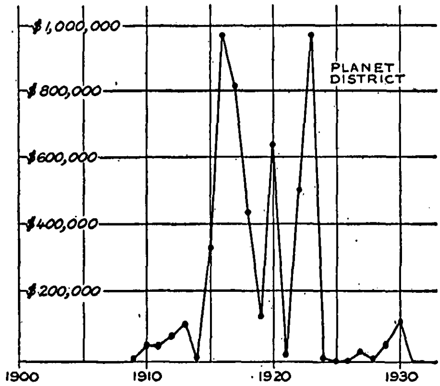

FIGURE 17.—Annual production of nonferrous metals in Planet district, Arizona, 1909–32.

Plomosa.[70]—5 to 30 miles from railroad at Bouse. Gold, copper, and lead veins and lodes in metamorphic rocks and intrusives; gold placers. This district, which is very poorly defined, was discovered in 1862. The placers appear to have yielded moderately in the early days, but there seems to have been very little activity in the lode mines until after 1900. Since 1904 the district has made a fairly regular small annual output. There was some small-scale work going on early in 1934. Recorded production, 1904–32, 5,519 tons of ore yielding, with the placers, 6,235.78 oz. Au, 35,822 oz. Ag, 528,603 lbs. Cu, 57,647 lbs. Pb, valued in all at $245,058. These figures probably include the output of the properties in the Dome Rock Mountains, which by some are considered to be in the La Paz district.

Sheep Tanks.[71]—30 miles from railroad at Vicksburg. Gold-bearing lode in highly manganiferous brecciated zone in Tertiary volcanic rocks. The district was discovered in 1909 but made no production until 1929, when 801 tons of ore containing 1,303.27 oz. Au and 12,525 oz. Ag, valued at $33,514, was shipped. The company was reorganized in 1931, and in 1934 a 100-ton mill was treating the ore. The higher-grade ore appears to occur near the outcrop; at a distance of about 100 feet from the surface, assays show a gold content of less than 0.2 ounce to the ton. (See p. 84.)

Silver (Eureka).[72]—40 to 50 miles from railroad at Dome. Silver-lead veins in Tertiary volcanic rocks and pre-Tertiary rocks. The district was discovered about 1862 but was relatively inactive until about 1879. Considerable difficulty was encountered in treating the ores, owing largely to the lack of water at the mines, but a production of more than $1,500,000 in lead and silver was made between

[70] Bancroft, Howland, op. cit., pp. 87–95. Wilson, E. D., op. cit. (Bull. 133), pp. 31–32; (Bull. 137), pp. 134–135. Hamilton, Patrick, op. cit., p. 138.
[71] Wilson, E. D., op. cit. (Bull. 134), pp. 132–141; (Bull. 137), pp. 143–147.
[72] Wilson, E. D., op. cit. (Bull. 134), pp. 50–73. Hamilton, Patrick, op. cit., pp. 136–138.

1879 and 1889. Since 1893 but little work has been done. Recorded production, 1904–32, 2,969 tons of ore yielding 4.23 oz. Au, 28,695 oz. Ag, 534 lbs. Cu, 120,636 lbs. Pb, valued in all at $28,000.

CALIFORNIA

IMPERIAL COUNTY

Imperial County[73] was separated from San Diego County late in 1907. From 1908 through 1932 the county has produced 156,704 tons of ore yielding 26,353.54 oz. Au, 56,235 oz. Ag, 29,681 lbs. Cu, 55,979 lbs. Pb, valued in all at $601,442 (fig. 18). The greater part of this output has come from the Cargo Muchacho and Picacho districts.

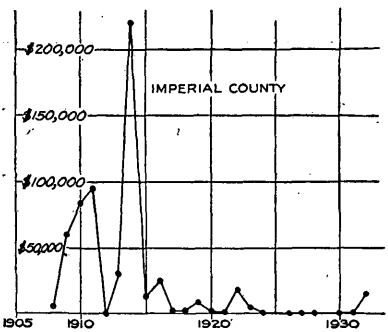

FIGURE 18.—Annual production of nonferrous metals in Imperial County, Calif., 1908–32.

● *Cargo Muchacho (Hedges, Ogilby)*.[74]—4 to 10 miles from railroad at Ogilby. Gold-bearing lodes in gneiss and schist cut by pegmatites. The district was known in early times and yielded some gold from dry placers. Lode mining probably began about 1877 and yielded $167,000 up to 1882. The district was idle from then to 1890, when mining was revived. It was actively worked through 1904. There have been spasmodic operations since then, particularly in 1911 and 1913–16, during which one of the properties was optioned to a large mining concern. Early in 1934 there were a few small lode properties working, and the tailings at the Tumco mine were being re-treated. The total production of the district is probably about $3,000,000, of which about $400,000 has been produced since 1907. (See p. 177.)

Mesquite.[75]—7 miles from railroad at Glamis. Gold placers and lodes in schist. The placers are reported to have been productive in the early days but have yielded very little in recent years.

Paymaster (Gold Basin) district.[76]—25 to 35 miles from railroad at Glamis. Silver-lead veins in gneiss and schist; some gold lodes. The silver-lead veins were discovered in 1867 and yielded consider-

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[73] Merrill, F. J. H., Geology and mineral resources of San Diego and Imperial Counties, Calif., pp. 93–113, California State Min. Bur., 1914. Tucker, W. B., Imperial County, Calif.: California State Min. Bur. Rept. 22, pp. 248–285, 1926.

[74] Merrill, F. J. H., op. cit., pp. 95–99. Tucker, W. B., op. cit., pp. 252–254. Brown, J. S., The Salton Sea region, Calif.: U. S. Geol. Survey Water-Supply Paper 497, p. 258, 1923.

[75] Merrill, F. J. H., op. cit., p. 101. Tucker, W. B., op. cit., pp. 258–259.

[76] Merrill F. J. H., op. cit., pp. 102–103. Tucker, W. B., op. cit., pp. 252–253, 257, 262, 264. Brown, J. S., op. cit., p. 256.

able oxidized ore between that date and 1880. Since that time several attempts have been made to work the sulphide ore but with little success. The gold deposits to the east were discovered about 1917 but have produced little, although some prospecting was going on early in 1934. The total production from the district is possibly about $1,000,000, but less than $50,000 has been produced since 1907.

Pegleg.[77]—15 miles from railroad at Niland. Reported to contain gold-bearing quartz veins in granite. Little is known about the deposits in this district, but their production appears to have been negligible.

Picacho.[78]—25 miles from railroad at Yuma, Ariz. Gold-bearing lodes in gneiss and schist; gold placers. The district is said to have been known since 1857. Early activity was probably almost entirely confined to placer mining on a small scale; larger-scale operations were attempted unsuccessfully in the nineties. Lode mining seems to have been done largely in the period 1904–10. There is some evidence that the ore mined was surficially enriched. In recent years the only work has been sporadic minor dry washing. The total production of the district is unknown but is probably less than $1,000,000. The output since 1907 has been less than $150,000.

INYO COUNTY

In 1902–32 Inyo County[79] produced 984,256 tons of ore, yielding 209,270.92 oz. Au, 5,307,050 oz. Ag, 3,053,168 lbs. Cu, 123,055,157 lbs. Pb, 26,853,611 lbs. Zn, valued in all at $19,408,297 (fig. 19). The Cerro Gordo, New Coso (Darwin), Resting Springs (Tecopa), Skidoo, and Chloride Cliff districts have provided a large proportion of this total. The production prior to 1902 was probably about $15,000,000.

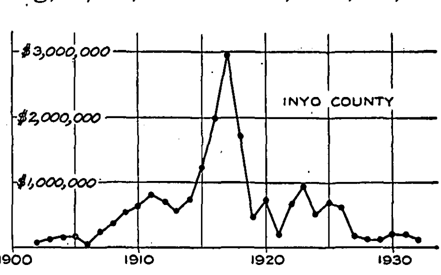

FIGURE 19.—Annual production of nonferrous metals in Inyo County, Calif., 1902–32.

Alabama Hills (*Lone Pine*).[80]—5 miles from railroad at Lone Pine. Placer gold; gold quartz veins in granitic rocks. The placers were exhausted prior to 1888, but there has been sporadic small activity on the lode deposits. The production since 1902 has prob-

[77] Tucker, W. B., op. cit., p. 260. Brown, J. S., op. cit., p. 174.

[78] Merrill, F. J. H., op. cit., pp. 99–102. Tucker, W. B., op. cit., pp. 252, 256, 258, 260–262.

[79] Goodyear, W. A., Inyo County: California State Min. Bur. Rept. 8, pp. 224–288, 1888. Fairbanks, H. W., Inyo County: California State Min. Bur. Rept. 12, pp. 472–478, 1894. Tucker, W. B., Inyo County: California State Min. Bur. Rept. 22, pp. 453–530, 1926.

[80] Goodyear, W. A., op. cit., pp. 243–244. Fairbanks, H. W., op. cit., p. 475. Tucker, W. B., op. cit., p. 474.

ably been less than $10,000 and prior to that date was possibly not much greater.

Beveridge.[81]—10 miles from railroad at Owenyo. Gold quartz veins in granitic rocks and the bordering sediments. The district was discovered in 1877 and yielded a fairly large production. In recent years it appears to have been relatively inactive. The production since 1902 is unknown but probably small; that prior to 1902 may have been more than $100,000.

Carbonate.[82]—40 miles from railroad at Zabriskie. Oxidized lead-silver replacement deposits in limestone. The Queen of Sheba group of claims is the only property of importance; it shipped ore from 1914 to 1918 and has been sporadically active since that time. The total production is possibly about $200,000.

● *Cerro Gordo (Belmont).*[83]—3 to 10 miles from railroad at Keeler. Oxidized lead-silver-zinc replacement bodies in limestone; silver-bearing quartz veins. The district was discovered in 1865, and yielded largely between 1869 and 1877. It revived about 1908 and since that time has been one of the dominant producing districts in the county. Oxidized zinc ore was first mined in 1907, and a large amount was produced in 1911–20. The peak production was reached in 1917, but there has been a moderately large continuing production since that time. Early in 1934 activities in the district were largely confined to lessees' operations on the Cerro Gordo and a few other properties. The production of the district has been estimated at $15,000,000, of which about $8,000,000 has been produced since 1902.

● *Chloride Cliff (Keane Wonder).*[84]—15 to 25 miles from railroad at Beatty, Nev., or Death Valley Junction. Gold-bearing quartz veins or lodes in Paleozoic sedimentary rocks. The district was discovered about 1903, and the Keane Wonder mine is reported to have made a production of $1,100,000 between about 1908 and 1916. There has been a continuing small production, and early in 1934 several small operations were going on.

Coso.[85]—10 miles from railroad at Olancha. Gold-bearing veins in granitic rocks; gold placers. The district was discovered in 1860; it has been relatively inactive in recent years. The early production, which appears to have been large, although its amount is uncertain,

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[81] Tucker, W. B., op. cit., pp. 465–466, 467, 469, 470, 471. Fairbanks, H. W., op. cit., p. 475.

[82] Tucker, W. B., op. cit., p. 480.

[83] Tucker, W. B., op. cit., pp. 477, 480–482, 483–484, 485, 495, 497–498, 503. Goodyear, W. A., op. cit., pp. 228, 250–256. Knopf, Adolph, A geologic reconnaissance of the Inyo Range and the eastern slope of the southern Sierra Nevada, Calif.: U. S. Geol. Survey Prof. Paper 110, pp. 108–116, 1918.

[84] Tucker, W. B., op. cit., pp. 467, 470. Ball, S. H., A geologic reconnaissance in southwestern Nevada and eastern California: U. S. Geol. Survey Bull. 308, pp. 173–175, 1907.

[85] Tucker, W. B., op. cit., pp. 472–473. Fairbanks, H. W., op. cit., p. 474.

is said to have been made from the oxidized parts of the sulphide-rich ores. A small amount of quicksilver was produced in 1935.

Daylight.[86]—15 miles from railroad at Beatty, Nev. Quartz veinlets in rhyolite. The region was prospected at the time of the mining boom of 1903 to 1905, but there appears to have been no production.

Deep Springs.[87]—25 to 30 miles from railroad at Big Pine. Veins and replacement deposits of gold, copper, lead, and silver in granitic rocks and intruded sediments. The district has been known for many years, but the output appears to have been small. There seems to have been very little recent activity.

Echo Canyon (*Schwaub*).[88]—12 miles from railroad at Death Valley Junction. Gold quartz veins in Paleozoic sedimentary rocks. The district probably had a brief period of activity about 1905–7 but appears to have produced little. Some small shipments have been reported in recent years.

Emigrant (*Lemoigne*).[89]—60 miles from railroad at Beatty, Nev. Replacement bodies of lead ore in limestone. The deposit has been known for many years, but the production is probably limited to shipments of some 250 tons valued at about $15,000.

Goldbelt.[90]—40 miles from railroad at Keeler. Gold-copper veins in quartz monzonite. The district was discovered about 1905. There has probably been only minor development and no production.

● *Greenwater.*[91]—15 miles from railroad at Death Valley Junction. The district enjoyed a notable boom in 1906–8, but the deposits proved a disappointment and the camp was abandoned. Some shipments made by lessees during the periods of high copper prices, 1916–18 and 1929, may have had a value of more than $10,000. There was no activity early in 1934.

Harrisburg.[92]—55 miles from railroad at Trona. Gold-bearing quartz veins in sedimentary and intrusive rocks. The district was discovered in 1905 and yielded considerable ore in 1906–10; some ore was mined by lessees in 1912–16. The district was inactive early in 1934. It is reported that no ore was found below a depth of 150 feet. The total production may have been as much as $250,000.

Kelley.—20 miles from railroad at Brown. Very little is known of this district, which appears to include the western slope of the

[86] Ball, S. H., op. cit., p. 176.

[87] Tucker, W. B., op. cit., pp. 464, 472, 482, 488–489. Knopf, Adolph, op. cit., pp. 116, 119.

[88] Ball, S. H., op. cit., p. 175.

[89] Tucker, W. B., op. cit., p. 488.

[90] Ball, S. H., op. cit., p. 211.

[91] Tucker, W. B., op. cit., pp. 463–464. Zalinski, E. R., Some notes on Greenwater, the new copper district of California: Eng. and Min. Jour., vol. 83, pp. 77–82, 1907. Boyle, O. M., Jr., The Greenwater mining district, Calif.: California Jour. Technology, vol. 10, pp. 29–32, August 1907.

[92] Tucker, W. B., op. cit., pp. 466–467, 469.

Argus Mountains. The gold production has probably been small, especially in recent years.

Leadfields (Grapevine).[93]—22 miles from railroad at Beatty, Nev. Disseminated galena in Paleozoic limestone. Ore was first discovered here in 1905, but little work was done until 1924–25, when a minor boom occurred. This soon collapsed and the district is now abandoned. There appears to have been no production.

Lee.[94]—25 to 30 miles from railroad at Keeler. Lead-silver zinc replacement deposits in limestone. The district has been sporadically productive, and the Santa Rosa mine is reported to have shipped more than $300,000 worth of oxidized ores. There appears to have been a continuing rather small production in recent years.

Lees Camp.[95]—6 miles from railroad at Leeland Siding, Nev. Gold-quartz veins in Paleozoic sedimentary rocks. This is probably one of the districts active at the time of the Bullfrog boom, but there seems to have been little or no production.

●*Modoc (Lookout).*[96]—30 miles from railroad at either Keeler or Trona. Chiefly lead-silver or zinc replacement bodies in limestone. The district, which includes the north end of the Argus Range, is an old one, and has not been very active in recent years. The production since 1902 is possibly about $50,000, much of it zinc ore; prior to 1902 the Modoc mine is reported to have produced nearly $2,000,000.

●*New Coso (Darwin).*[97]—25 miles from railroad at Keeler. Lead-silver bodies in altered limestone near granitic dikes. The deposits were discovered about 1876, and a large production was made in the next few years. A long period of relative inactivity followed, but the district revived about 1913, and from then until about 1927 a considerable production was made. The total production is possibly somewhat more than $5,000,000, of which $2,000,000 or $3,000,000 was made prior to 1902.

Nopah.—5 to 15 miles from railroad at Shoshone. Lead-silver deposits in sedimentary rocks. Little is definitely known concerning this district, and its production has been relatively small.

Panamint.[98]—40 miles from railroad at Trona. Silver-rich quartz veins in metamorphosed sedimentary rocks. The district is reported to have been discovered in 1858, but was not actively worked until 1873. In the succeeding 4 or 5 years a large output of silver was

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[93] Tucker, W. B., op. cit., pp. 504–510.
[94] Idem, pp. 463, 488, 498–499.
[95] Ball, S. H., op. cit., p. 175.
[96] Tucker, W. B., op. cit., pp. 471, 490, 503. Fairbanks, H. W., op. cit., p. 474.
[97] Knopf, Adolph, The Darwin silver-lead mining district, Calif.: U. S. Geol. Survey Bull. 580, pp. 1–18, 1915. Tucker, W. B., op. cit., pp. 482–489, 498, 500, 504. Goodyear, W. A., op. cit., pp. 224–226.
[98] MacMurphy, F., Geology of the Panamint silver district, Calif.: Econ. Geology, vol. 25, pp. 305–325, 1930.

made. There has been only minor activity in the district in recent years. The total production has been estimated at $2,000,000.

Poison Spring.[99]—16 miles from railroad at Leeland Siding, Nev. Quartz veins in Paleozoic sedimentary rocks. There appears to have been only minor prospecting in this district and probably no production.

●*Resting Springs (Tecopa).*[1]—5 to 10 miles from railroad at Tecopa. Lenticular bodies of oxidized lead-silver ore along fissures in Paleozoic sedimentary rocks. The district was discovered in 1865, but the output was relatively small until about 1910. From 1912 to 1927 there was a fairly continuous operation and a rather large quantity of ore was mined. Since that time only small shipments have been made. The total output is perhaps about $5,000,000.

Saratoga.[2]—10 to 20 miles from railroad at Tecopa. Gold quartz lodes and lead-silver deposits in pre-Cambrian and Paleozoic rocks. This poorly defined district, which extends into San Bernardino County, has long been known, but its production appears to have been relatively small. There was some prospecting early in 1934. The output since 1902 has probably been less than $50,000 and that prior to 1902 may have been even smaller.

●*Skidoo (Tucki Mountain).*[3]—65 miles from railroad at Trona. Gold-quartz veins in granitic gneiss. The district was discovered about 1906 and yielded largely from 1908 to about 1917 but is now essentially abandoned. The total production is reported to be about $1,500,000.

●*Slate Range (Trona, Argus).*[4]—7 to 15 miles from railroad at Trona. Lead-bearing lodes and replacement bodies in limestone; gold-quartz veins in granite. The district has been known since 1861. The production prior to 1915 probably came largely from gold ores. The bulk of the output since that time has been lead ore from the Ophir and Slate Range mines. There was only moderate activity in the region early in 1934. The total output appears to be more than $500,000, in large part since 1902.

South Park (Ballarat).[5]—30 to 40 miles from railroad at Trona. Chiefly gold-quartz veins in schist. The district appears not to have been active until the nineties, and the bulk of the known production was made in 1896–1905. There has been only minor activity in recent years. The total output is reported to be about $500,000.

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[99] Ball, S. H., op. cit., p. 175.

[1] Tucker, W. B., op. cit., pp. 478–479, 485, 491–492, 497, 503–504.

[2] Idem, pp. 468–469, 474, 493–494.

[3] Idem, p. 473.

[4] Fox, J. M., Developing a prospect: Eng. and Min. Jour., vol. 123, pp. 883–888, 1927. Tucker, W. B., op. cit., pp. 472, 479, 487–488, 492–493, 500, 501.

[5] Sampson, R. J., Mineral resources of a part of the Panamint Range: California State Min. Bur. Rept. 28, pp. 357–376, 1932.

Swansea (*Keeler*).—This term appears to have been used in the past for part of the Cerro Gordo district.

Tibbets.[6]—5 miles from railroad at Aberdeen. Gold-quartz veins and lodes in granite. The district has been known since the sixties, but the production appears to have been relatively small.

Ubehebe.[7]—50 to 60 miles from railroad at Keeler. Lead-silver bodies in limestone; contact copper deposits. The district was discovered about 1875 but has never been highly productive owing to its distance from a railroad and lack of water. Some shipments of ore, chiefly lead-silver, have been made, but the total value appears to have been considerably less than $50,000.

Union (*Russ*, *Independence*).[8]—5 miles from railroad at Kearsarge. Lead-silver bodies in limestone; gold-quartz veins in granitic rocks. This is an old district (discovered in 1860) and has provided a somewhat sporadic and rather small output in recent years. The total production is unknown, but probably that since 1902 has been materially less than $100,000. The output prior to 1902 was more than $2,000,000.

Waucoba (*Paiute*).[9]—About 25 miles from railroad at Big Pine. Chiefly lead-silver deposits in limestone. The district has been known since the seventies and has yielded a sporadic production. There does not appear to have been much activity in recent years, and the total output is unknown.

● *Wildrose*.[10]—50 miles from railroad at Trona. Stibnite veins and gold-quartz veins in schist. This is a poorly defined district north of the Panamint district. There has been sporadic activity for many years in the region, and 35 percent antimony ore is reported to have been shipped from 1915 to 1919. The district was essentially inactive early in 1934. The total output is unknown but is probably small.

Willow (*Ashford*).[11]—15 to 30 miles from railroad at Shoshone. Gold-quartz veins in schist. The deposits have yielded a small production on several occasions, but the output since 1902 has probably been less than $100,000. Very little work was being done early in 1934.

KERN COUNTY

In 1902–32 Kern County[12] produced 3,548,036 tons of ore yielding 751,946.71 oz. Au, 1,914,189 oz. Ag, 419,930 lbs. Cu, and 82,809

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[6] Knopf, Adolph, op. cit. (Prof. Paper 110), pp. 119–120.

[7] Tucker, W. B., op. cit., pp. 463, 464, 465, 470, 477–478, 496, 501.

[8] Knopf, Adolph, op. cit. (Prof. Paper 110), pp. 120–123. Tucker, W. B., op. cit., pp. 464, 466, 496, 501–502.

[9] Knopf, Adolph, op. cit., pp. 116, 120. Tucker, W. B., op. cit., pp. 483, 491, 492.

[10] Sampson, R. J., op. cit., pp. 357–376.

[11] Tucker, W. B., op. cit., pp. 469, 470.

[12] Tucker, W. B., and Sampson, R. J., Gold resources of Kern County: California State Min. Bur. Rept. 29, pp. 271–339, 1933. Tucker, W. B., Kern County: California State Min. Bur. Rept. 25, pp. 20–81, 1929.

lbs. Pb, valued in all at $16,750,410 (fig. 20). These figures include the output from districts not considered in this report, but by far the greater part of the total has come from the Randsburg, Mojave, and Rosamond districts. The county production prior to 1902 amounted to about $8,000,000, of which nearly half may have come from districts not considered here.

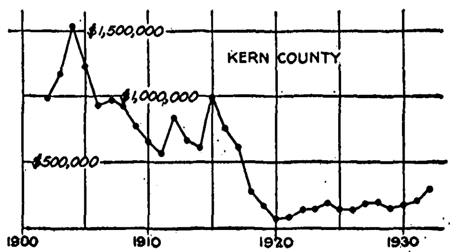

FIGURE 20.—Annual production of nonferrous metals in Kern County, Calif., 1902–32.

Goler (*Garlock*, *Black Mountain*).[13]—5 to 10 miles from railroad at Garlock. Chiefly gold placers; some gold- and copper-bearing quartz veins in schist. The dry placers were actively worked for several years after 1893, although they were known before that time. There has been some minor activity in the placers since 1929, but the absence of water has prevented any large-scale work. The production is said to be more than $100,000, the great bulk of which was made before 1902.

●*Mojave*.[14]—5 miles or less from railroad at Mojave. Gold-silver veins in Tertiary volcanic rocks. The district was discovered in 1894 and produced considerable ore until about 1910. It revived briefly in 1922 and again in 1931. Late in 1933 the Silver Queen deposit was discovered, and the operators are reported to have developed a very large body of rich ore. All the older mines have apparently been relatively unsuccessful in their search for ore below ground-water level. The total output of the district is believed to be somewhat in excess of $3,000,000, about half of which was made prior to 1902.

Rademacher.[15]—5 miles from railroad at Searles. Quartz veins with gold or lead-silver minerals in granite. The district was probably discovered in the nineties but has had very little development. There has been some minor activity in recent years. The total output is probably less than $10,000.

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[13] Nason, F. L., The Goler gold diggings, Calif.: Eng. and Min. Jour., vol. 59, p. 223, 1890. Fairbanks, H. W., Red Rock, Goler, and Summit mining districts in Kern County: California State Min. Bur. Rept. 12, pp. 456–458, 1894. Tucker, W. B., op. cit., pp. 23, 24, 29. Tucker, W. B., and Sampson, R. J., op. cit., pp. 279, 281, 302, 306–307, 322, 328. Hulin, C. D., Geologic features of the dry placers of the northern Mohave Desert: California State Min. Bur. Rept. 30, pp. 417–425, 1934.

[14] Bateson, C. E. W., The Mohave mining district of California: Am. Inst. Min. Eng. Trans., vol. 37, pp. 160–177, 1907. DeKalb, Courtney, Geology of the Exposed Treasure lode, Mohave, Calif.: Idem, vol. 38, pp. 310–319, 1909. Tucker, W. B., and Sampson, R. J., op. cit., pp. 279, 280, 283–284, 298–299, 300, 301, 311, 326, 334, 338–339. Schroter, G. A., A geologist visits the Mohave mining district: Eng. and Min. Jour., vol. 136, pp. 185–188, 1935.

[15] Tucker, W. B., and Sampson, R. J., op. cit., pp. 279, 284–285, 294, 303–304, 305, 309–310, 315, 317, 327, 334, 339. Tucker, W. B., op. cit., pp. 57, 59.

● *Randsburg.*[16]—Railroad at Johannesburg. Gold lodes and veins in gneiss, schist, and granite. The district was discovered in 1895 and has yielded continuously since that time. Its production in most years has been a large proportion of the county total. The Yellow Aster mine has been the largest producer but since 1918 has been worked chiefly by lessees. Early in 1934 several properties were active in the district, and at the Yellow Aster mine a sampling campaign was in progress and a tailings retreatment plant was being operated. The total production of the district is probably somewhat more than $15,000,000, of which $3,000,000 may have been produced prior to 1902. (See also p. 51.)

● *Red Rock.*[17]—5 miles from railroad at Cantil. Chiefly gold placers. The district was discovered in the nineties and made a moderate production from the dry washing of the gravel. There was only minor activity early in 1934. The lode deposits in the region do not appear to have been productive. The production prior to 1902 is unknown, and since that time the district has yielded less than $10,000.

● *Rosamond.*[18]—5 miles from railroad at Rosamond. Gold-silver lodes and veins in Tertiary volcanic rocks. The Tropico mine, the only important productive property, has yielded a rather regular moderate output for many years and was being operated early in 1934. The total production of the district has been estimated at $500,000.

San Antonio (Dove Springs).[19]—10 miles from railroad at Cantil. Gold-quartz veins in granitic rocks. The district is said to have been discovered in 1887 but appears never to have been very productive. There was some activity in the region early in 1934.

● *Stringer.*[20]—5 miles from railroad at Johannesburg. Narrow but rich gold-quartz veins in schist and granite; gold placers. The district adjoins the Randsburg district on the south, and probably its moderate output has been included in the estimated production given for that district.

Summit.[21]—Along Owenyo branch of Southern Pacific Railroad. Gold placers. Here, as in the Goler and Red Rock districts, the scarcity of water has made it necessary to work the gravel by dry washing. Several large-scale operations have been unsuccessful. Many individuals have been working in the district in recent years,

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[16] Hulin, C. D., Geology and ore deposits of the Randsburg quadrangle, Calif.: California State Min. Bur. Bull. 95, 1925. Hess, F. L., Gold mining in the Randsburg quadrangle, Calif.: U. S. Geol. Survey Bull. 430, pp. 23–47, 1910.

[17] Fairbanks, H. W., op. cit., pp. 456–458. Tucker, W. B., and Sampson, R. J., op. cit., pp. 293–294, 296–297, 323–324. Hulin, C. D., op. cit. (Rept. 30), pp. 417–425.

[18] Tucker, W. B., and Sampson, R. J., op. cit., pp. 280, 330–332.

[19] Idem, pp. 307, 326.

[20] Hulin, C. D., op. cit. (Bull. 95); Hess, F. L., op. cit.

[21] Fairbanks, H. W., op. cit., pp. 456–458. Hulin, C. D., op. cit. (Rept. 30), pp. 417–425. Tucker, W. B., and Sampson, R. J., op. cit., pp. 279, 319–320, 322, 328.

but their total output has been small. The richer material worked in the nineties, however, is reported to have yielded considerable gold.

RIVERSIDE COUNTY

In 1902–32 Riverside County [22] produced 18,715 tons of ore yielding 8,895.89 oz. Au, 30,098 oz. Ag, 251,546 lbs. Cu, 715,732 lbs. Pb, valued in all at $297,982 (fig. 21). The Eagle Mountains, Pinyon Mountain, and Bendigo districts have yielded a large proportion of this total.

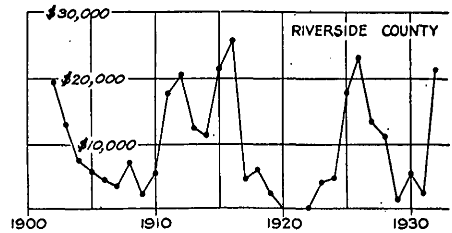

FIGURE 21.—Annual production of nonferrous metals in Riverside County, Calif., 1902–32.

Arica (Blythe Junction).[23]—6 miles from railroad at Rice (formerly Blythe Junction). Gold-bearing veins in metamorphic rocks. A few properties have been intermittently active in this district and have yielded a small production, possibly less than $10,000.

●*Bendigo (Vidal)*.[24]—5 to 10 miles from railroad at Vidal. Gold and copper-bearing quartz veins in schist. The district probably was first active about 1898 and has been worked sporadically since then. There was some activity on the Alice property early in 1934. The total production from several of the properties is believed to have been less than $50,000, chiefly in gold and copper.

Chuckwalla (Pacific, Hathaway).[25]—50 miles from railroad at Blythe or Mecca. Chiefly gold-quartz veins in granite or granite gneiss. The district has been known for many years and apparently made a small to moderate production in the eighties and nineties. The shipments since 1902 appear to have been small in number and value, probably less than $10,000. There was only minor activity early in 1934.

Dos Palmas.[26]—15 to 20 miles from railroad at Salton. Gold-quartz veins in metamorphic rocks. There appears to have been very little production from the properties in this district, particularly in recent years.

[22] Merrill, F. J. H., Mines and mineral resources of Los Angeles, Orange, and Riverside Counties, California State Min. Bur., 1917. Tucker, W. B., and Sampson, R. J., Riverside County: California State Min. Bur. Rept. 25, pp. 468–526, 1929.

[23] Brown, J. S., The Salton Sea region, California: U. S. Geol. Survey Water-Supply Paper 497, p. 261, 1923. Tucker, W. B., and Sampson, R. J., op. cit., pp. 476–477, 481. Merrill, F. J. H., op. cit., pp. 81–82.

[24] Merrill, F. J. H., op. cit., pp. 82–84. Tucker, W. B., and Sampson, R. J., op. cit., pp. 472, 473, 477, 479, 482, 486–488.

[25] Merrill, F. J. H., op. cit., pp. 78–80. Tucker, W. B., and Sampson, R. J., op. cit., pp. 472, 473, 477, 480, 483, 485, 487, 489, 491. Brown, J. S., op. cit., pp. 241, 272.

[26] Merrill, F. J. H., op. cit., p. 81. Tucker, W. B., and Sampson, R. J., p. 477.

●*Eagle Mountains* (*Monte Negro*).[27]—50 miles from railroad at Mecca. Gold-bearing lode in limestone near contact with quartz monzonite; silver-lead-copper vein in quartzite. The Iron Chief mine is reported to have produced $150,000 in gold ore, probably in large part prior to 1902, and the Black Eagle or Maleta group about $60,000 in lead, silver, and copper in 1923–28. Placer gold was recovered in this region in the nineties. The only activity early in 1934 was some small-scale dry washing.

Hodges.[28]—8 miles from railroad at Ripley. Reported to be gold-bearing veins in granite. There appears to have been a small production prior to 1913, which probably had a total value of less than $10,000. No recent activity has been reported.

Maria.[29]—5 to 10 miles from railroad at Mineral Switch. Gold- and copper-bearing lodes and veins in metamorphic rocks. There are several prospects in the district, but the production appears to have been negligible. Very little activity has occurred in recent years.

McCoy (*Ironwood*).[30]—15 to 20 miles from railroad at Blythe. Copper-gold lodes and veins in metamorphosed rocks. There has been more or less activity in this district at various times in the past but relatively little production. The total output is probably less than $10,000.

Palen.[31]—20 miles from railroad at Mineral Switch. Copper deposits in metamorphosed rocks. There has probably been only minor prospecting done in this district, and, so far as known, little or no production.

●*Pinyon Mountain.*[32]—20 to 30 miles from railroad at Indio or Banning. This poorly defined district has long been known and has yielded considerable amounts of gold from quartz veins in schist and gneiss and the igneous rocks intrusive into them. Several properties were operating early in 1934 and yielding a small output of gold. The bulk of the output from the district has come from the Lost Horse and New El Dorado mines, the former being credited with a production of about $350,000. The total production of the district is probably about $500,000, of which possibly $100,000 has been mined since 1902.

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[27] Tucker, W. B., and Sampson, R. J., op. cit., pp. 471, 474–476, 482, 484. Harder, E. C., Iron-ore deposits of the Eagle Mountains, Calif.: U. S. Geol. Survey Bull. 503, 1912.

[28] Merrill, F. J. H., op. cit., p. 81. Tucker, W. B., and Sampson, R. J., op. cit., pp. 481, 483.

[29] Merrill, F. J. H., op. cit., p. 82. Tucker, W. B., and Sampson, R. J., op. cit., pp. 469–470, 487, 491. Brown, J. S., op. cit., pp. 259–260.

[30] Merrill, F. J. H., op. cit., p. 65. Tucker, W. B., and Sampson, R. J., op. cit., pp. 467, 470, 471. Brown, J. S., op. cit., pp. 242–243, 263.

[31] Merrill, F. J. H., op. cit., pp. 66–67. Tucker, W. B., and Sampson, R. J., op. cit., pp. 470–471. Brown, J. S., op. cit., pp. 240, 263–264, 276.

[32] Merrill, F. J. H., op. cit., pp. 75–76. Tucker, W. B., and Sampson, R. J., op. cit., pp. 477, 478, 481, 483, 485–486. Brown, J. S., op. cit., pp. 266–267.

San Jacinto.[33]—25 miles from railroad at Hemet. Gold-quartz veins in granite or gneiss. There has been a small sporadic production for several years. The total output since 1902 is probably about $10,000.

● *Virginia Dale.*[34]—This district is the extension into Riverside County of the district of the same name in San Bernardino County. It has also been known as the Monte Negro district. Gold-bearing quartz veins in granitic rocks have been prospected and have probably yielded a small output. The San Bernardino County portion of the district appears to have been much more productive. (See p. 54.)

● *Washington (Gold Park).*[35]—30 miles from railroad at Banning. Gold-bearing quartz veins in granitic and gneissic rocks. The district is the southern continuation of the Twenty-nine Palms district in San Bernardino County and appears to have no very sharp boundary with the adjoining Pinyon Mountain district to the south. Small or moderate amounts of development work have been done on a number of the properties, but the production appears to have been small.

SAN BERNARDINO COUNTY

In 1902–32, San Bernardino County[36] produced 1,185,926 tons of ore yielding 289,049.55 oz. Au, 19,660,035 oz. Ag, 10,387,880 lbs. Cu, 5,183,878 lbs. Pb, 1,353,957 lbs. Zn, valued in all at $23,630,037 (fig. 22). The Rand and Stedman districts together account for a very large proportion of this total. The production of the county prior to 1902 was perhaps about $20,000,000, much of which came from the Calico district.

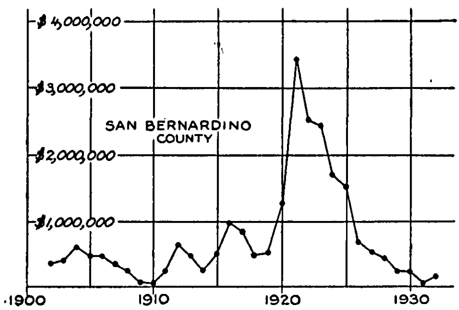

FIGURE 22.—Annual production of nonferrous metals in San Bernardino County, Calif., 1902–32.

● *Adelanto.*[37]—11 miles from railroad at Oro Grande. Lead-zinc sulphide veins in limestone. There has been a minor

[33] Merrill, F. J. H., op. cit., p. 75. Tucker, W. B., and Sampson, R. J., op. cit., p. 481.

[34] Merrill, F. J. H., op. cit., pp. 76–78. Tucker, W. B., and Sampson, R. J., op. cit., pp. 478–479, 483–484, 487, 488.

[35] Tucker, W. B., and Sampson, R. J., op. cit., pp. 472–473, 476, 479–480, 484–485.

[36] Tucker, W. B., and Sampson, R. J., San Bernardino County: California State Min. Bur. Rept. 26, pp. 202–325, 1930. Cloudman, H. C., Huguenin, E., and Merrill, F. J. H., Mines and mineral resources of San Bernardino County, California State Min. Bur., 1917. Crossman, J. H., San Bernardino County—its mineral and other resources: Min. and Sci. Press, vol. 61, 1890; vol. 62, 1891 (numerous scattered references).

[37] Tucker, W. B., and Sampson, R. J., op. cit., pp. 267–268.

amount of exploratory work done in this district, but, so far as known, no production.

● *Alvord.*[38]—6 miles from railroad at Yermo. Gold quartz veins in granite or schist. The district has been known for many years and is reported to have produced $50,000 prior to 1892. It has been sporadically active in recent years but the production has been small.

Arrowhead (*Hidden Hills*).[39]—20 to 25 miles from railroad at Fenner. Gold-quartz veins, some of which are narrow but of high grade, in granitic rocks. The district was discovered in 1878 and has been worked in a small way at several times. The total output is reported to be more than $100,000, but there has been little activity in recent years.

● *Atolia.*[40]—On railroad. Gold placers; gold-quartz veins in granitic rocks. Discovered in the late nineties and yielded an early production of more than $100,000 in gold. The tungsten deposits have provided most of the production in recent years, but there is still a small sporadic output, especially from the dry washing of gravel. (See p. 90.)

Bear Valley.[41]—40 miles from railroad at Victorville. Gold placers; gold lodes in metamorphic rocks. The placers were probably discovered in the fifties, and the lode mines appear to have had their maximum activity in the eighties and nineties. There has been more or less activity in recent years, but the output has been small. The total production, however, is reported to amount to several hundred thousand dollars.

Blackhawk (*Silver Reef*).[42]—35 to 40 miles from railroad at Victorville. Gold and silver deposits in crushed limestone overlying gneiss; gold placers. The district was organized in 1870 but was not actively worked until the nineties, when an unsuccessful attempt at mining took place. Another revival of interest began a few years ago, and considerable work was done in an effort to mine the low-grade ores. It was reported early in 1934 that the Arlington mine

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38 Storms, W. H., California State Min. Bur. Rept. 11, pp. 359–360, 1892. Crossman, J. H., op. cit. (vol. 61), p. 315. Tucker, W. B., and Sampson, R. J., op. cit., pp. 222, 243–244.

39 Cloudman, H. C., and others, op. cit., pp. 26–27. Crossman, J. H., op. cit. (vol. 62), p. 2. Tucker, W. B., and Sampson, R. J., op. cit., pp. 240–241, 243, 260.

40 Hess, F. L., Gold mining in the Randsburg quadrangle, Calif.: U. S. Geol. Survey Bull. 430, p. 45, 1910. Hulin, C. D., Geology and ore deposits of the Randsburg quadrangle, Calif.: California State. Min. Bur. Bull. 95, 1925. Tucker, W. B., and Sampson, R. J., op. cit., pp. 233, 253–254.

41 Crossman, J. H., op. cit. (vol. 61), p. 185. Cloudman, H. C., and others, op. cit., pp. 20–23. Tucker, W. B., and Sampson, R. J., op. cit., pp. 222, 237, 246, 250.

42 Crossman, J. H., op. cit. (vol. 61), p. 233. Cloudman, H. C., and others, op. cit., pp. 23–24, 54–56. Storms, W. H., op. cit., pp. 364–366. Tucker, W. B., and Sampson, R. J., op. cit., pp. 222, 231, 242–243. Woodford, A. O., and Harris, T. F., Geology of Blackhawk Canyon, San Bernardino Mountains, Calif.: California Univ., Dept. Geol. Sci., Bull., vol. 17, pp. 265–304, 1928.

was being sampled. The total output is unknown but possibly does not exceed $100,000.

● *Bullion* (*Standard*, *Kewanee*).[43]—8 to 15 miles from railroad at Cima or Ivanpah. Chiefly copper deposits in altered limestone; also gold-quartz veins and lead-silver deposits. The district was discovered many years ago and has yielded a moderate amount of copper and lead-silver ores. It has been inactive in recent years. The total output may amount to $300,000, a large part of which has been made since 1902.

● *Calico*.[44]—3 to 5 miles from railroad at Yermo. Silver-rich veins, lodes, and disseminated deposits in Tertiary lavas and pyroclastic rocks. The district was discovered in 1879 and from 1881 to 1893 yielded a large production of silver from relatively shallow oxidized ores. Since 1893 work has been done largely by lessees on a small scale, although at least two more pretentious attempts have been made to revive the district. The total output has been estimated at $10,000,000, by far the greater part of which was made prior to 1902. (See p. 149.)

● *Cave Springs*.—30 miles from railroad at Sperry. There has been only minor prospecting on small base-metal deposits in gneiss and schist and probably no production.

Coolgardie.[45]—15 miles from railroad at Barstow. Gold placer gravel, worked on a small scale since 1900 by dry washing. The total output is reported to be $100,000 but has been relatively small in recent years.

● *Crackerjack*.—25 miles from railroad at Silver Lake. Gold-quartz veins in granitic rocks. This district does not appear to be sharply defined from the Cave Springs district. There has been a small amount of prospecting, some of it in recent years, but apparently very little production.

Dry Lake.[46]—50 miles from railroad at Victorville. Gold-bearing veins in granite; lead-silver deposits. The district has been known for many years but appears never to have been particularly active or productive.

Fremont Peak.[47]—This district is not shown on sheet I but is about 20 miles southeast of Randsburg. Gold-quartz veins in granitic

[43] Crossman, J. H., op. cit. (vol. 61), p. 379. Tucker, W. B., and Sampson, R. J., op. cit., pp. 205, 214, 216–217, 220, 244, 270. Hewett, D. F., Geology and ore deposits of the Ivanpah quadrangle, Nev.-Calif.: U. S. Geol. Survey Prof. Paper — (in preparation).

[44] Lindgren, Waldemar, The silver mines of Calico, Calif.: Am. Inst. Min. Eng. Trans., vol. 15, pp. 717–734, 1887. Storms, W. H., op. cit., pp. 337–345. Weeks, F. B., Possibilities of the Calico mining district: Eng. and Min. Jour., vol. 119, pp. 757–763, 1925. Tucker, W. B., and Sampson, R. J., op. cit., pp. 269, 271–272, 279, 285–286, 286–287, 289–291.

[45] Tucker, W. B., and Sampson, R. J., op. cit., pp. 232, 260.

[46] Crossman, J. H., op. cit. (vol. 61), p. 229. Tucker, W. B., and Sampson, R. J., op. cit., p. 234.

[47] Tucker, W. B., and Sampson, R. J., op. cit. pp. 235, 253, 255.

rocks were discovered about 1920 and have been more or less prospected since that time. The total output is probably less than $10,000. Some work was reported in progress in 1934.

Gold Reef (Clipper Mountain).[48]—5 miles from railroad at Danby. Gold-bearing veins and lodes in volcanic rocks. One of the properties in the district was prospected by the Tom Reed Co., of Oatman, in 1917–18, apparently with unsatisfactory results. The total output is unknown but is probably small.

● *Goldstone.*[49]—35 miles from railroad at Barstow. Gold-quartz veins in schist and limestone, and gold placers. District was discovered in 1915 and was the scene of a minor boom. There have been several small shipments and early in 1934 prospecting of the lode deposits was going on, together with some dry washing of the placers.

● *Grapevine (Barstow, Camp Rochester).*[50]—2 to 10 miles from railroad at Barstow. Silver-rich veins in Tertiary volcanic rocks; gold-copper quartz veins in schist. The district was probably discovered about the same time as Calico. One of the mines is reported to have made a large production of silver. There have been only relatively small scale operations in recent years, although prospecting is continuing. The total output appears to be more than $1,000,000, largely prior to 1902. (See p. 149.)

● *Halloran Springs.*[51]—15 miles from railroad at Baker. Chiefly gold-quartz veins in granitic rocks. Several properties in the district have been prospected in recent years, and one of them was producing gold early in 1934. The total output of the district, however, appears to be relatively small.

● *Hart.*[52]—15 miles from railroad at Ivanpah. Gold-bearing veinlets and zones in silicified and altered volcanic rocks. The district was discovered in 1907 and was the scene of a small boom. Activity continued until about 1913, a small production being made in several years. There appears to have been a mild revival in interest during the last few years. The total output from the camp probably has not greatly exceeded $10,000. (See p. 173.)

Hickorum.[53]—10 miles from railroad at Bagdad. Copper-gold veins in igneous rocks. The district has been known and explored for several years but appears never to have been very productive. The total output is probably considerably less than $100,000.

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[48] Tucker, W. B., and Sampson, R. J., op. cit., pp. 231, 237–238.

[49] Cloudman, H. C., and others, op. cit., pp. 30–33. Tucker, W. B., and Sampson, R. J., op. cit., pp. 220, 227, 238–239, 249–250.

[50] Crossman J. H., op. cit. (vol. 61), p. 299. Tucker, W. B., and Sampson, R. J., op. cit., pp. 214, 219, 287.

[51] Tucker, W. B., and Sampson, R. J., op. cit., p. 213. Hewett, D. F., op. cit.

[52] Hewett, D. F., op. cit.

[53] Tucker, W. B., and Sampson, R. J., op. cit., pp. 213, 214, 217.

Holcomb.[54]—25 miles from railroad at Victorville. Gold placers; gold lodes in granitic and metamorphic rocks. The placers were discovered in 1859 and the shallow, easily worked deposits were soon exhausted. Several attempts have been made since that time to work the remaining material on a large scale, for the most part unsuccessfully. There has been another revival of interest in recent years, and a small annual production is recorded. The total output is unknown but probably amounts to several hundred thousand dollars.

Ibex (Needles).[55]—5 to 15 miles from railroad at Needles. Copper-gold quartz veins in igneous rocks. The district has been known and prospected at least since 1888 and has yielded sporadic small shipments. The total output probably is about $10,000.

● *Ivanpah (Copper World, Clark Mountain).*[56]—10 to 20 miles from railroad at Calada or Nipton. Silver-rich veins in dolomite; contact copper deposits. The district was discovered in 1868, and considerable quantities of silver were produced between 1870 and 1880. The copper deposits yielded a little ore in 1869, but the chief periods of activity on them were in 1898, 1906–08, and 1916–20. There has been only small-scale activity in recent years. The total output of the district is probably close to $4,000,000, of which about $2,500,000 represents the silver production.

● *Kingston Range.*[57]—15 to 20 miles from railroad at Tecopa or Morrison siding. Lead-silver lodes or replacement deposits in Cambrian dolomite. The district, which extends into Inyo County, has yielded a sporadic output of ore in the last 30 years. The total value of the production is probably close to $25,000.

Kramer Hills.[58]—9 miles from railroad at Kramer. Gold lodes and disseminated deposits in schist. The district was discovered in 1926 and caused a minor boom. A few small shipments have been made, but the ore is apparently too low in grade to be profitably worked at this locality.

Lava Beds (Newberry).[59]—10 to 20 miles from railroad at Lavic or Newberry. Lead-silver veins in igneous rocks or replacement deposits in limestone. The district was discovered about 1890 and yielded some lead-silver ore, probably less than $100,000. It has been worked

[54] Crossman, J. H., op. cit. (vol. 61), p. 185. Cloudman, H. C., and others, op. cit., pp. 24–25. Tucker, W. B., and Sampson, R. J., op. cit., pp. 241, 245, 250.

[55] Tucker, W. B., and Sampson, R. J., op. cit., pp. 206–207, 214. Storms, W. H., op. cit., p. 368.

[56] Crossman, J. H., op. cit. (vol. 61), pp. 363, 379. Tucker, W. B., and Sampson, R. J., op. cit., pp. 207, 209, 214, 231, 267–269, 274, 277, 279, 280, 284–286. Hewett, D. F., op. cit.

[57] Tucker, W. B., and Sampson, R. J., op. cit., p. 284. Hewett, D. F., op. cit.

[58] Tucker, W. B., and Sampson, R. J., op. cit., pp. 221–222, 250–251.

[59] Crossman, J. H., op. cit. (vol. 61), p. 299. Tucker, W. B., and Sampson, R. J., op. cit., pp. 275, 277–278, 280–281, 282, 283–284, 285. Storms, W. H., op. cit. (Rept. 11), pp. 349–359; Certain ore deposits: Min. and Sci. Press, vol. 64, p. 18, 1892.

at intervals since that time but appears never to have produced any considerable quantity of ore. It was essentially inactive early in 1934.

Lead Mountain.[60]—A poorly defined district 10 to 20 miles from railroad at Bagdad or Amboy. Lead-silver veins in volcanic rocks; gold-quartz veins in granitic rocks. The district was discovered in the eighties and probably yielded a small to moderate production of lead and silver from the War Eagle mine. In 1934 one of the gold properties was being developed, and the War Eagle dumps were being re-treated.

Lytle Creek (San Antonio).[61]—2 to 15 miles from railroad at Keenbrook or other stations. Chiefly gold placers. The Lytle Creek placers were discovered in 1860, and those of San Antonio in 1882. There was a revival of interest in 1894, but the production in recent years has been small. The lode mines appear never to have been productive. The total output is unknown but may have been about $100,000.

● *Monumental (Whipple Mountain).*[62]—5 to 15 miles from railroad at Calzona or Drennan. Copper-bearing lodes and veins in schist and gneiss. The deposits were known for many years but were not actively prospected until about 1910. Since that time there have been a number of small shipments, but there was essentially no activity early in 1934. The total output is probably less than $50,000.

Morongo (Lone Valley).[63]—46 miles from railroad at Seven Palms. Gold quartz veins in granitic rocks. The district has long been known and is believed to have produced about $150,000 prior to 1890. It does not appear to have been active in recent years.

● *Morrow.*[64]—30 miles from railroad at Barstow or Johannesburg. Copper veins in granitic rocks. There has been only minor prospecting of these deposits and probably no production.

● *New York (Barnwell, Manvel).*[65]—3 to 15 miles from railroad at Cima, Brant, or Ivanpah. Chiefly quartz veins containing silver, lead, and copper in quartz monzonite or in sedimentary rocks adjacent to it. The district was discovered in 1861 but was not actively worked until 1873. It has been sporadically active on several occasions since that time, but there appears to have been

[60] Crossman, J. H., op. cit. (vol. 61), p. 299. Tucker, W. B., and Sampson, R. J., op. cit., pp. 229, 286.

[61] Crossman, J. H., op. cit. (vol. 61), p. 185. Cloudman, H. C., and others, op. cit., pp. 19–20.

[62] Tucker, W. B., and Sampson, R. J., op. cit., pp. 206, 207, 209, 210, 220. Bancroft, Howland, Reconnaissance of the ore deposits in northern Yuma County, Ariz.: U. S. Geol. Survey Bull. 451, pp. 68–73, 1911.

[63] Cloudman, H. C., and others, op. cit., p. 26. Crossman, J. H., op. cit. (vol. 61), p. 233. Tucker, W. B., and Sampson, R. J., op. cit., pp. 238, 244–246.

[64] Tucker, W. B., and Sampson, R. J., op. cit., pp. 207, 214.

[65] Crossman, J. H., op. cit. (vol. 61), p. 379. Tucker, W. B., and Sampson, R. J., op. cit., pp. 213, 220, 275–277. Hewett, D. F., op. cit.

very little work done in the last few years. The total output probably amounts to several hundred thousand dollars; since 1902 about $200,000, chiefly in silver, has been produced.

Old Woman.[66]—15 to 20 miles from railroad at Milligan or Danby. Quartz-sulphide veins, valuable chiefly for silver and gold, in granitic rocks. The district was known in 1890 but appears not to have been productive until the present century. Several properties were active early in 1934. The total output is unknown, but the production since 1902 is probably about $50,000.

Ord (Belleville).[67]—A poorly defined district that is reached either from Daggett or Newberry (10 to 15 miles) or Victorville (30 to 45 miles). Gold or gold-copper quartz veins in various kinds of igneous rocks; gold placers. The district was discovered about 1866, but little work was done until much later. The placers were first worked in 1894. The properties have been sporadically operated on several occasions but were relatively inactive early in 1934. The total output of the district is unknown but is probably small.

●*Paradise.*[68]—20 miles from railroad at Barstow. Gold-quartz veins in dioritic rocks. The district was known prior to 1888, and ore has been mined here at several times. The Olympus mine was active early in 1934. The ore appears to be of rather low grade, and the total output has probably been small.

●*Randsburg.*[69]—On railroad. Silver-rich veins in schist. The Kelly-Rand silver bonanza was discovered in 1919 and since that time has produced nearly $15,000,000 in silver and gold. The extremely rich ore stimulated intense prospecting throughout the adjoining region, and several shafts were sunk and lateral exploration extended from them, but no important ore bodies were found beyond the immediate vicinity of the original discovery. The Kelly-Rand mine reached the peak of its production in 1921, and thereafter the output declined rather rapidly to 1931, when less than $100,000 was produced. In 1934 the mine was producing at the rate of 175 tons a day, owing to the increased price of silver, and it was reported that 75,000 tons of ore with a value of more than $6.50 a ton was developed. Continuance of operations apparently requires maintenance of a relatively high silver price. (See p. 42.)

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[66] Crossman, J. H., op. cit. (vol. 62), p. 18. Tucker, W. B., and Sampson, R. J., op. cit., pp. 215–216, 279–280, 281.

[67] Crossman, J. H., op. cit. (vol. 61), p. 201. Tucker, W. B., and Sampson, R. J., op. cit., pp. 207, 215, 217–218, 230–231, 236, 239–240, 242, 247, 249.

[68] Tucker, W. B., and Sampson, R. J., op. cit., p. 246.

[69] Hulin, C. D., Geology and ore deposits of the Randsburg quadrangle, Calif.: California State Min. Bur. Bull. 95, 1925. Carpenter, J. A., The Kelly silver mine at Randsburg, Calif.: Eng. and Min. Jour., vol. 108, pp. 940–943, 1919; A sagebrush silver producer: Eng. and Min. Jour., vol. 112, pp. 132–135, 1921. Parsons, A. B., The California Rand silver mine: Min. and Sci. Press, vol. 123, pp. 667–675, 855–859, 1921; vol. 124, pp. 11–17, 1922.

Saratoga.[70]—An extension of the district with the same name in Inyo County. There was only minor activity in this part of the district in 1934. The Amargosa mine is reported to have produced about $300,000 many years ago.

●*Shadow Mountains.*[71]—20 to 25 miles from railroad at Silver Lake. Quartz veins containing copper, gold, silver, and lead in gneissic and granitic rocks. The district was known prior to 1895 and has made sporadic small shipments. The total value of the output is probably less than $10,000.

Sidewinder.[72]—15 miles from railroad at Victorville. Gold quartz veins in granitic rocks. The Sidewinder deposit was probably discovered before 1885, and the mine has been active on several occasions since that time; some work was being done in the district early in 1934. The total output is unknown but is probably less than $100,000.

●*Signal* (*Goffs*, *Vontrigger*).[73]—10 to 15 miles from railroad at Goffs. Gold and copper veins and disseminated deposits in granitic and gneissic rocks; gold-rich quartz stringers in rhyolite. The district was known and had made small shipments prior to 1890; it has been worked several times since then, the last extensive operations being in 1926–29. The total output is probably close to $100,000, most of which has been made since 1902.

Silver Lake.[74]—A poorly defined district 1 to 10 miles from railroad at Silver Lake. Probably all of the reported output of $200,000 has come from the Riggs mine, where small lenses of silver ore occur in limestone. (See p. 178.)

●*Silver Mountain* (*Oro Grande*).[75]—1 to 10 miles from railroad at Oro Grande or Victorville. Chiefly gold-quartz veins and lodes in various kinds of wall rocks; some contact copper deposits. The district was discovered prior to 1880 and was very active between 1880 and 1890. In recent years there have been several shipments, but the work has been on a small scale. The total output of the district is unknown; that since 1902 appears to have been relatively small. (See p. 169.)

Slate Range.—15 to 20 miles from railroad at Trona. A southern continuation of the district with the same name in Inyo County.

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[70] Cloudman, H. C., and others, op. cit., pp. 47–48.

[71] Tucker, W. B., and Sampson, R. J., op. cit., p. 210. Hewett, D. F., op. cit. Riddell, G. C., and Foster, E. D., Geology and ore deposits of the Shadow Mountains: Arizona Min. Jour., vol. 11, pp. 3–6, Nov. 15, 1927.

[72] Crossman, J. H., op. cit. (vol. 61), p. 266. Tucker, W. B., and Sampson, R. J., op. cit., pp. 219–220, 226, 227, 242, 252.

[73] Crossman J. H., op. cit. (vol. 62), p. 18. Tucker, W. B., and Sampson, R. J., op. cit., pp. 207, 213–214, 255. Hewett, D. F., op. cit.

[74] Tucker, W. B., and Sampson, R. J., op. cit., pp. 220, 267, 268.

[75] Crossman, J. H., op. cit. (vol. 61), pp. 266, 282. Storms, W. H., op. cit. (Rept. 11), pp. 360–364. Cloudman, H. C., and others, op. cit., pp. 36–41. Tucker, W. B., and Sampson, R. J., op. cit., pp. 205–206, 222, 234, 237, 240, 247–248, 253, 260, 274.

Reported to have produced small amounts of gold ore but does not appear to have an output that approaches that of the northern part of the district.

Soda Lake.—This poorly defined district appears to include the region west of Baker and is 5 to 20 miles from the railroad. The gold- and silver-bearing veins and contact copper deposits have been sporadically prospected and at times have yielded a small production.

● *Solo*.[76]—This district, which was known prior to 1890, originally included a much larger area than that to which the name is now locally applied. It lies east and south of Baker and is 10 to 20 miles from the railroad at that point. Mines on the gold-quartz veins in gneissic rocks have been sporadically active, and several properties were doing exploratory work early in 1934. The district output has come in large part from the Paymaster mine since 1900 and is reported to be from $50,000 to $100,000.

● *Stedman (Ludlow)*.[77]—5 to 12 miles from railroad at Ludlow. The narrow-gage road from Ludlow to Stagg is no longer usable. Gold or gold-copper-silver flat-lying lodes in volcanic rocks. The district was known prior to 1888, but the bulk of the production was made from about 1900 to 1907 and from 1911 to 1918, by the Bagdad-Chase and Roosevelt mines (Pacific Mines Corporation). The tailings from the Barstow mill of this company have been reworked at intervals for several years. There have been several revivals of the district since 1918, and early in 1934 three or more properties were being actively prospected, and some gold was being produced.[78] The total production of the district probably amounts to about $5,000,000, in large part since 1902.

● *Twenty-nine Palms (Gold Park)*.[79]—50 miles from railroad at Banning. Gold-quartz veins in granitic rocks. The district has been sporadically active for many years, and a little gold has been produced recently. The total output appears to be not much more than $10,000.

● *Vanderbilt*.[80]—4 miles from railroad at Ivanpah. Gold-quartz veins in gneissic rocks. The district was very active from about 1893 to 1896 and may have produced in excess of $100,000 at that time. Small shipments have been made on several occasions since then, and early in 1934 two properties were active. The output since 1902 probably has not exceeded $20,000.

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[76] Hewett, D. F., op. cit. Crossman, J. H., op. cit. (vol. 61), p. 315.

[77] Tucker, W. B., and Sampson, R. J., op. cit., pp. 218–219.

[78] Tucker, W. B., Current mining activity in southern California: California State Min Bur. Rept. 30, pp. 323, 325–326, 1934.

[79] Tucker, W. B., and Sampson, R. J., op. cit., p. 222.

[80] Storms, W. H., op. cit. (Rept. 11), pp. 367–368. Cloudman, H. C., and others, op. cit., p. 42. Tucker, W. B., and Sampson, R. J., op. cit., pp. 232–233, 236–237, 255–259. Hewett, D. F., op. cit.

●*Virginia Dale.*[81]—45 miles from railroad at Amboy or Mecca. Gold-quartz veins in granitic and gneissic rocks. The district was discovered in the eighties and made a considerable production of gold from about 1900 to 1915, chiefly from oxidized ores, the material below ground-water level being difficult to mill successfully. Since 1915 there has been rather sporadic activity, but several properties have produced small amounts of ore in the last few years. The total output is probably close to $1,000,000, most of which has been produced since 1902.

NEVADA

CLARK COUNTY

●*Alunite* (*Railroad Pass, Vincent*).[82]—2 to 4 miles from railroad at Boulder City. Gold-bearing veins in much-altered igneous rocks. The district was discovered prior to 1908 and has been prospected at intervals since then. There was only minor activity in the district early in 1934. No recorded production up to 1932, but some shipments are reported. (See p. 145.)

●*Bonelli Peak.*—40 miles from railroad at St. Thomas. Gold-bearing lodes in schist and granitic rocks. The deposits have been worked in a small way for many years. One property was shipping ore early in 1934. No recorded production, but a small output is reported locally.

●*Bunkerville* (*Key West, Copper King*).[83]—15 miles from railroad at St. Thomas. Copper-nickel-platinum ore in lenticular basic dikes cutting pre-Cambrian gneiss. The district was discovered about 1901, and several unsuccessful attempts have been made to work the mines in which the nickel-platinum ore is found. Recorded production, 1908–32, 1,550 tons of ore yielding 51.39 oz. Au, 1,313 oz. Ag, 99,990 lbs. Cu, and 26,597 lbs. Pb, valued in all at $19,726. (See pp. 87–88.)

●*Charleston.*—35 miles from railroad at Las Vegas. Oxidized lead-zinc replacement ores in dolomitized limestone. Small quantities of ore valued in all at less than $5,000 were shipped in 1926, 1927, and 1929. There has been little or no activity in the district since that time.

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[81] Crossman, J. H., op. cit. (vol. 61), p. 299. Storms, W. H., op. cit. (Rept. 11), pp. 368–369. Cloudman, H. C., and others, op. cit., pp. 27–29. Tucker, W. B., and Sampson, R. J., op. cit., pp. 227–229, 234–235, 238, 240–243, 246, 254–255, 259–260.

[82] Lincoln, F. C., Mining districts and mineral resources of Nevada, pp. 16–17, Reno, 1923. Hill, R. T., A scientific search for a new gold field: Eng. and Min. Jour., vol. 86, pp. 1157–1160, 1908; Camp Alunite, a new Nevada gold district: Idem, pp. 1203–1206.

[83] Lincoln, F. C., op. cit., pp. 18–19. Bancroft, Howland, Platinum in southeastern Nevada: U. S. Geol. Survey Bull. 430, pp. 192–199, 1910. Lindgren, Waldemar, and Davy, W. M., Nickel ores from Key West mine, Nev.: Econ. Geology, vol. 19, pp. 309–319, 1924.

● *Crescent.*[84]—6 miles from railroad at Nipton, Calif. Gold- and silver-bearing veins and disseminated deposits in gneissic rocks. The district was discovered in 1895 and revived in 1905. Two properties were active early in 1934, and some ore was being milled. Probably incomplete figures for the production from 1906 to 1932 give 432 tons of ore containing gold, silver, lead, and copper, valued at $7,655. The production prior to 1906 is unknown but probably very small. (See p. 170.)

● *Dike.*—1 mile from railroad at Dike. Lead ore replacing dolomitized limestone along fractures. Relatively little work has been done in the district, which was inactive in 1934, and only one shipment of high-grade lead ore, valued at less than $5,000, has been reported.

● *Eldorado Canyon.*[85]—20 miles from Boulder Canyon branch railroad. Gold- and silver-bearing lodes in pre-Cambrian gneiss but related to Tertiary volcanic rocks. The district was discovered in 1857 and organized as the Colorado district in 1861. It was actively worked for some time, and the production prior to 1907 is estimated at $2,000,000 to $5,000,000. Recorded production, 1907–32, 102,936 tons of ore yielding 42,436.82 oz. Au, 772,087 oz. Ag, 9,146 lbs. Cu, 69,448 lbs. Pb, 1,800 lbs. Zn, valued in all at $1,488,005. Of this $1,200,000 was produced in 1915–20 (fig. 23). There has been a moderate yield in recent years, however, and several properties were more or less active early in 1934.

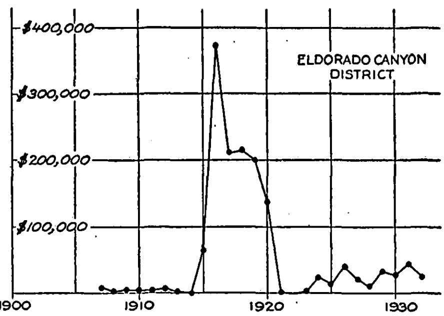

FIGURE 23.—Annual production of nonferrous metals in Eldorado Canyon district, Nevada, 1907–32.

● *Gass Peak.*[86]—12 miles from railroad at Valley station. Oxidized zinc ore replacing dolomitized limestone along shear zones. 1,000 tons of ore shipped in 1916–17, yielding 8.25 oz. Au, 2,418 oz. Ag, 16,707 lbs. Pb, 620,650 lbs. Zn, valued in all at $82,637. There has been little or no activity since 1917.

● *Gold Butte.*[87]—28 miles from railroad at St. Thomas. Replacement deposits of oxidized copper ore in limestone; gold quartz lodes in granitic rocks. The district was discovered about 1905 and made

[84] Lincoln, F. C., op. cit., p. 19. Ransome, F. L., Preliminary account of Goldfield, Bullfrog, and other mining districts in southern Nevada: U. S. Geol. Survey Bull. 303, pp. 79–80, 1907.

[85] Lincoln, F. C., op. cit., pp. 19–20. Ransome, F. L., op. cit., pp. 63–76.

[86] Lincoln, F. C., op. cit., pp. 20–21.

[87] Lincoln, F. C., op. cit., p. 21. Hill, J. M., Notes on some mining districts in eastern Nevada: U. S. Geol. Survey Bull. 648, pp. 42–53, 1916.

several shipments of copper ore in 1912–18. There was some prospecting of the gold lodes early in 1934. Recorded production, 1912–32, 337 tons of ore yielding 3.01 oz. Au, 209 oz. Ag, 136,620 lbs. Cu, 10,206 lbs. Pb, 15,386 lbs. Zn, valued in all at $29,351.

Logan (*Muddy Mountains*, *St. Thomas*).—Shipments of copper ore and placer bullion, valued at less than $1,000, are recorded from this district, but its exact location is unknown. The district may possibly be synonymous with the Bunkerville or Gold Butte districts.

● *Searchlight*.[88]—24 miles from railroad at Nipton, Calif. Gold-bearing veins in gneissic rocks near a major fault. The veins are related to Tertiary volcanic rocks. The district was discovered in 1897 and reached its peak production in 1906. There has been a moderate continuing production since that time; and early in 1934 there was a fair amount of activity, chiefly by lessees. Recorded production, 1902–32, 411,762 tons of ore yielding 204,910.75 oz. Au, 209,936 oz. Ag, 646,052 lbs. Cu, 1,658,569 lbs. Pb, valued in all at $4,570,702 (fig. 24). The production prior to 1902 has been estimated at $1,000,000.

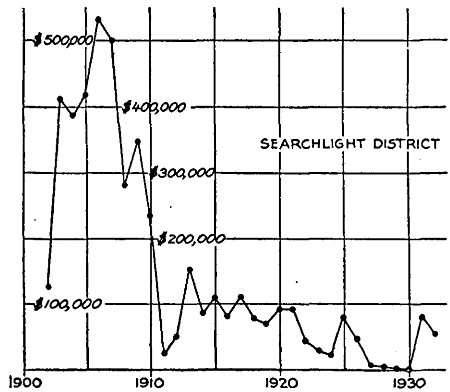

FIGURE 24.—Annual production of nonferrous metals in Searchlight district, Nevada, 1902–32.

● *Sunset* (*Lyons*).[89]—3 miles from railroad at Lyons. Gold-bearing breccia pipe in granitic gneiss. The district is said to have been discovered in 1897, but the Lucy Gray mine, the only important property, was opened in 1905. Recorded production, 1911–28, 1,601 tons of ore, containing chiefly gold and minor amounts of silver and lead, valued in all at $11,764. These figures are probably incomplete. There appears to have been little or no activity in the district since 1928.

● *Yellow Pine* (*Goodsprings*, *Potosi*).[90]—8 miles from railroad at Jean. Bodies of oxidized lead-zinc ore replacing dolomitized limestone; gold-bearing lodes along or near porphyritic intrusions.

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[88] Lincoln, F. C., op. cit., pp. 24–27. Ransome, F. L., op. cit., pp. 63–76. Callaghan, Eugene, Geology of the Searchlight district, Clark County, Nev.: Nevada Univ. Bull. — (in preparation).

[89] Lincoln, F. C., op. cit., pp. 27–28. Hewett, D. F., Geology and ore deposits of the Ivanpah quadrangle, Nev.-Calif.: U. S. Geol. Survey Prof. Paper — (in preparation).

[90] Lincoln, F. C., op. cit., pp. 29–33. Hewett, D. F., Geology and ore deposits of the Goodsprings quadrangle, Nev.: U. S. Geol. Survey Prof. Paper 162, 1931. Knopf, Adolph, A gold-platinum-palladium lode in southern Nevada: U. S. Geol. Survey Bull. 620, pp. 1–18, 1915.

The district was discovered in 1856 but yielded only small amounts of ore until the completion of the Union Pacific Railroad in 1905. It reached its peak production in 1916, under the stimulus of the prevailing high prices of lead and zinc. The production of lead and zinc since 1931 has been small, but there was considerable activity at the gold properties in 1934. According to Hewett,[91] "it is reasonable to assume that with greater understanding of the geologic relations of the deposits and with improved mining and milling technique considerable ore will be found and the district will be a source of production for many years." Recorded production, 1902-32, 489,096 tons of ore yielding 12,552.05 oz. Au, 1,799,629 oz. Ag, 3,336,458 lbs. Cu, 82,333,800 lbs. Pb, 193,481,847 lbs. Zn, valued in all at $24,345,673 (fig. 25). The production prior to 1902 was probably about $500,000, in large part gold from the Keystone mine.

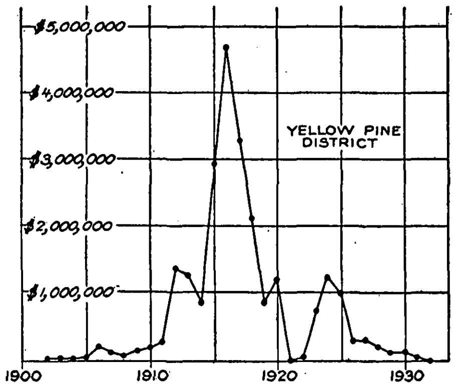

FIGURE 25.—Annual production of nonferrous metals in Yellow Pine district, Nevada, 1902–32.

ESMERALDA COUNTY

● *Cuprite.*[92]—15 miles from railroad at Goldfield. Base-metal veins and replacement bodies in Paleozoic limestone; silver-gold veins in Tertiary volcanic rocks. Several small lots of ore have been shipped from the district since its discovery in 1905, but their aggregate value probably does not exceed $10,000. There appears to have been no activity in the metalliferous deposits in recent years. (See pp. 148, 174.)

● *Divide (Gold Mountain).*[93]—6 miles from railroad at Tonopah. Rich silver ore is found in lodes or shear zones in late Tertiary pyroclastic rocks, the result of near-surface enrichment. Gold quartz veins were discovered in the region in 1901, but the silver ore was not found until 1917. Its richness resulted in the Divide boom of 1919. The district production, largely from one mine, was maintained at more than $100,000 annually from 1919 to 1929, except for 1924–25, but since that time has been essentially confined to leasing activities

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[91] Hewett, D. F., op. cit., p. vii.

[92] Lincoln, F. C., op. cit., pp. 63–64. Ball, S. H., A geologic reconnaissance in southwestern Nevada and southeastern California: U. S. Geol. Survey Bull. 308, pp. 69–71, 1907.

[93] Lincoln, F. C., op. cit., pp. 64–66. Knopf, Adolph, The Divide silver district, Nev.: U. S. Geol. Survey Bull. 715, pp. 147–170, 1921.

which still continue (fig. 26). Recorded production, 1911–32, 114,944 tons of ore, containing 18,666.39 oz. Au, 3,014,920 oz. Ag, and small amounts of lead and copper, valued in all at $2,864,120.

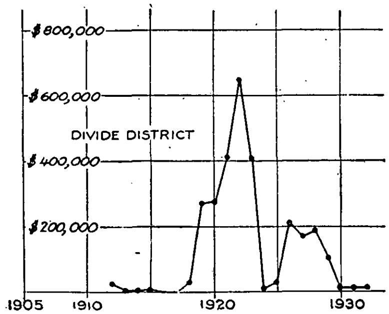

FIGURE 26.—Annual production of nonferrous metals in Divide district, Nevada, 1912–32.

● *Goldfield.*[94]—Terminus of railroad. The rich gold ore shoots are rather small and poorly defined bodies in irregular "ledges" composed of fractured and altered volcanic rocks. According to Locke, the ore has been localized by a major fracture. The district was discovered in 1902 and reached the peak of its production in 1910. Since 1920 the production has been relatively small, the bulk of the output since 1927 being derived from old tailings. Considerable interest has been shown recently in the district, however, and a fair amount of exploration work is going on. Recorded production, 1903–32, 5,346,247 tons of ore and tailings containing 4,105,951.07 oz. Au, 1,646,687 oz. Ag, 7,633,957 lbs. Cu, 33,490 lbs. Pb, valued in all at $87,218,797 (fig. 27).

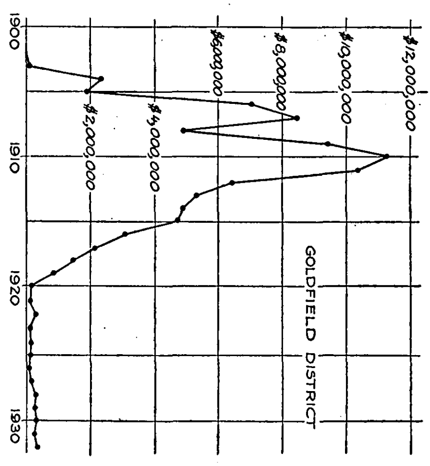

FIGURE 27.—Annual production of nonferrous metals in Goldfield district, Nevada, 1903–32.

● *Hornsilver* (*Goldpoint, Limepoint*).[95]—26 miles from railroad at Goldfield. Quartz veins valuable chiefly for gold and silver in Paleozoic sediments near border of granitic intrusives; probably enriched in silver near surface. The district was discovered about 1868, and some shipments are recorded in the eighties, but the early production was relatively small. The deposits were rediscovered in 1905 and have been actively worked at intervals since then. The major properties are now under one control, and exploration is

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[94] Lincoln, F. C., op. cit., pp. 67–73. Ransome, F. L., The geology and ore deposits of Goldfield, Nev.: U. S. Geol. Survey Prof. Paper 66, 1909; Geology and ore deposits of the Goldfield district, Nev.: Econ. Geology, vol. 5, pp. 301–311, 438–470, 1910. Locke, Augustus, The ore deposits of Goldfield, Nev.: Eng. and Min. Jour., vol. 94, pp. 797–802, 843–489, 1912.

[95] Lincoln, F. C., op. cit., pp. 73–75. Ransome, F. L., The Hornsilver district, Nev.: U. S. Geol. Survey Bull. 380, pp. 41–43, 1909. Turner, J. K., The Hornsilver mining district: Min. and Sci. Press, vol. 124, pp. 93–94, 1922.

going on. Recorded production, 1907–32, 34,053 tons of ore yielding 11,791.89 oz. Au, 420,730 oz. Ag, 7,197 lbs. Cu, 71,079 lbs. Pb, 17,680 lbs. Zn, valued in all at $686,348.

●*Klondyke* (*Southern Klondyke*).[96]—14 miles south of Tonopah and 2 miles east of railroad. Quartz veins valuable chiefly for silver in Paleozoic sedimentary rocks; probably some silver enrichment near the surface. The district was discovered in 1899 and yielded a small but rather regular production annually through 1924. The production since then has been of minor importance. There was some activity in the district in the spring of 1934. Recorded production, 1903–32, 16,606 tons of ore yielding 2,405.64 oz. Au, 425,583 oz. Ag, 10,861 lbs. Cu, 257,080 lbs. Pb, valued in all at $529,052. The production prior to 1903 probably was not more than $25,000.

●*Lida* (*Alida Valley, Tule Canyon*).[97]—30 miles from railroad at Goldfield. The ore, valuable chiefly for its silver and gold content, is found in Paleozoic sedimentary rocks as veins and irregular replacement bodies. The district was discovered in 1871 and made an early production of about $250,000. Interest revived in 1904, and since that time there has been a continuing small production (maximum annual yield of $26,062 in 1920). Recorded production, 1903–32, 7,774 tons of ore yielding 1,567.53 oz. Au, 122,672 oz. Ag. 80,150 lbs. Cu, 445,722 lbs. Pb, 5,783 lbs. Zn, valued in all at $175,460.

●*Montezuma*.[98]—9 miles from railroad at Goldfield. Veins valuable chiefly for lead and silver in Paleozoic sedimentary rocks. The district was discovered in 1867 and worked at intervals until 1887; during that period a production of about $500,000 is reported. Interest revived in 1905, and there have since been several small shipments. There has probably been little or no activity since 1931. Recorded production, 1908–31, 866 tons of ore yielding 124.28 oz. Au, 27,563 oz. Ag, 7,250 lbs. Cu, 730,981 lbs. Pb, valued in all at $69,602.

Palmetto (*Windypah, Fesler*).[99]—42 miles from railroad at Goldfield. Veins in Paleozoic sedimentary rocks and in granite. The district was discovered in 1866 and was active until about 1871. It revived in the eighties and again in 1903. A production of $6,500,000 in silver prior to 1900 is claimed, but this appears to be excessive. There was only minor activity early in 1934. Recorded production, 1905–32, 401 tons of ore yielding 154.72 oz. Au, 3,058 oz. Ag, 882 lbs. Cu, 46,568 lbs. Pb, valued in all at $8,856.

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[96] Lincoln, F. C., op. cit., pp. 75–76. Spurr, J. E., The Southern Klondyke district, Esmeralda County, Nev.: Econ. Geology, vol. 1, pp. 369–382, 1906.

[97] Lincoln, F. C., op. cit., pp. 76–77. Ball, S. H., op. cit., pp. 55–65. Root, W. A., The Lida mining district of Nevada: Min. World, vol. 31, pp. 123–125, 1909.

[98] Lincoln, F. C., op. cit., pp. 78–79. Ball, S. H., op. cit., pp. 55–64. Stretch, R. H., The Montezuma district, Nev.: Eng. and Min Jour., vol. 78, pp. 5–6, 1904.

[99] Lincoln, F. C., op. cit., pp. 79–80. Spurr, J. E., Ore deposits of the Silver Peak quadrangle, Nev.: U. S. Geol. Survey Prof. Paper 55, pp. 85–96, 1906.

●*Railroad Springs.*[1]—25 miles from railroad at Goldfield. Veins, valuable chiefly for gold, in Paleozoic sedimentary rocks. At the old Gold Hill mine, where the Imperial Development Co. was milling ore early in 1934, the vein consists largely of iron oxides and follows a fault. Sulphides are found on the 200-foot level and are reported to be barren. The district production appears to have been included in the figures for the Lida district.

Silver Peak (*Red Mountain*).[2]—20 miles from railroad at Blair Junction. Gold-bearing quartz veins in Paleozoic sediments intruded by granitic rocks. The district was discovered in 1863 and worked more or less actively until 1870. It was revived in 1906, and a large tonnage was treated annually until 1915, when the major company ceased operations and removed the branch railroad connecting Silver Peak with the Tonopah & Goldfield Railroad. Since 1915 there has been a steady annual production, probably in large part from lessees' operations, that has averaged near $50,000. Activity in the district has considerably increased in the last few years. Recorded production, 1903–32, 1,186,489 tons of ore yielding 323,085.64 oz. Au, 210,475 oz. Ag, 9,098 lbs. Cu, 129,461 lbs. Pb, valued in all at $6,809,775 (fig. 28). The production prior to 1903 was about $1,250,000.

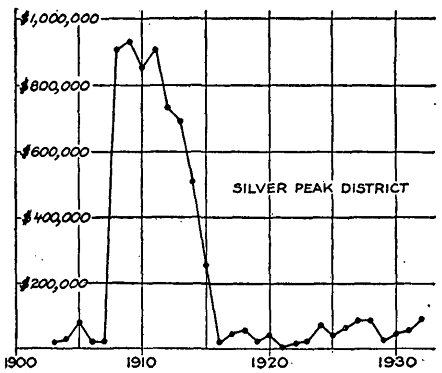

FIGURE 28.—Annual production of nonferrous metals in Silver Peak district, Nevada, 1903–32.

●*Stateline.*[3]—30 miles from railroad at Goldfield. Gold quartz veins in Paleozoic sedimentary rocks near contact with granitic rocks. First worked many years ago. The district was recently revived, and one property was being actively developed early in 1934. Production from the district has probably been included with that of Hornsilver or Tokop.

Sylvania (*Green Mountain*).[4]—50 miles from railroad at Goldfield. Veins in Paleozoic sedimentary rocks intruded by granite. The district was discovered in 1870 and worked for several years thereafter, a 30-ton lead furnace being used. There has been very little activity in recent years. The early production is unknown. Recorded production, 1906–32, 28 tons of ore valued, with the placer production, at $5,487. Gold, silver, and lead are present in the ores.

[1] Lincoln, F. C., op. cit., pp. 80–81. Ball, S. H., op. cit., pp. 55–63.
[2] Lincoln, F. C., op. cit., pp. 81–82. Spurr, J. E., op. cit.
[3] Ball, S. H., op. cit., p. 194.
[4] Lincoln, F. C., op. cit., p. 83.

● *Tokop* (*Bonnie Clare, Gold Mountain, Oriental Wash*).[5]—35 to 40 miles from railroad at Goldfield. Veins, valuable for gold, silver, and lead, in Paleozoic sedimentary rocks intruded by granitic rocks. The district was discovered in 1866 and made an early production estimated at $500,000. From 1902 to 1929 it yielded a rather regular but small output. Early in 1934 a small test mill was treating dump ore from one of the properties, and additional prospecting was planned. Recorded production, 1902–32, 8,338 tons of ore yielding 3,180.33 oz. Au, 28,400 oz. Ag, 8,029 lbs. Cu, 190,311 lbs. Pb, valued in all at $98,974.

LINCOLN COUNTY

Atlanta (*Silver Park, Silver Springs*).[6]—47 miles from railroad at Pioche. Silver-rich ore bodies in breccia zones related to Tertiary volcanic rocks. The district was discovered in 1869 and made an early production of $50,000 to $100,000 from small rich ore shoots. It was revived in 1906 and made some small shipments of silver ore, valued at less than $10,000, between 1913 and 1920. It appears to have been inactive in recent years.

● *Chief* (*Caliente*).[7]—8 miles from railroad at Caliente. Veins valuable chiefly for gold in Paleozoic quartzite. The district was organized in 1870 and yielded possibly $25,000 in the next few years. Some milling was done in 1911 and in 1912–13. In recent years a sporadic small production has been made by lessees, several of whom were working early in 1934. Recorded production, 1907–32, 6,690 tons of ore yielding 1,410.46 oz. Au, 5,883 oz. Ag, 6,129 lbs. Cu, 65,283 lbs. Pb, valued in all at $39,406.

● *Comet*.[8]—14 miles from railroad at Pioche. The limestone, 40 to 50 feet thick, which has been correlated with the limestone locally known as the "Combined Metals bed" in the Pioche shale of the Pioche district, is reported to be extensively replaced by a low-grade silver-lead-zinc sulphide ore, assaying on the average 3 ounces of silver to the ton, 3 to 4 percent of lead, and 4 to 6 percent of zinc. The sulphides occur in a gangue of iron-manganese carbonate. The Comet-Coalition Mining Co. is now developing the district and believes that a considerable tonnage of ore is present. The company plans not only to recover the silver, lead, and zinc, but also to make manganese alloys out of the carbonate gangue. The district was discovered in 1882, but very little work appears to have been done

[5] Lincoln, F. C., op. cit., pp. 83–84. Ball, S. H., op. cit., pp. 182–195. Ransome, F. L., Preliminary account of Goldfield, Bullfrog, and other mining districts in southern Nevada: U. S. Geol. Survey Bull. 303, pp. 80–83, 1907.

[6] Lincoln, F. C., op. cit., p. 118. Hill, J. M., Notes on some mining districts in eastern Nevada: U. S. Geol. Survey Bull. 648, pp. 114–120, 1916.

[7] Lincoln, F. C., op. cit., pp. 118–119. Callaghan, Eugene, Geology of the Chief district, Lincoln County, Nev.: Nevada Univ. Bull., vol. 30, no. 2, 1936.

[8] Lincoln, F. C., op. cit., p. 119. Westgate, L. G., and Knopf, Adolph, Geology and ore deposits of the Pioche district, Nev.: U. S. Geol. Survey Prof. Paper 171, p. 75, 1932.

until recent years. Recorded production, 1913–32, 2,792 tons of ore yielding 167.54 oz. Au, 48,531 oz. Ag, 7,176 lbs. Cu, 231,420 lbs. Pb, valued in all at $64,924.

Eagle Valley (*Fay*, *Stateline*).[9]—21 miles from railroad at Modena, Utah. Gold- and silver-bearing veins in Tertiary volcanic rocks. The district was discovered about 1896 and was the scene of considerable activity for a few years thereafter. There was essentially no activity between 1916 and 1930, but some production has been made since that time. Recorded production, 1903–32, 11,840 tons of ore yielding 3,693.24 oz. Au, 12,795 oz. Ag, and small amounts of copper and lead, valued in all at $84,556. The production prior to 1903 is not known.

Fairview (*Silverhorn.*)[10]—6 to 10 miles from narrow-gage railroad at Jackrabbit. Silver-bearing zones in silicified dolomite and silver-lead replacement deposits in dolomite. The Fairview deposit was discovered many years ago but appears never to have been highly productive. The Silverhorn region, to the west, was discovered about 1920, and considerable excitement resulted at the time, but there has been no activity in the last few years. Recorded production, 1916, 1917, and 1920, 114 tons of ore, valuable chiefly for lead but containing also some silver, gold, and copper, valued at less than $5,000. Other shipments may be included in the production of the Pioche district.

●*Ferguson* (*Delamar*).[11]—32 miles from railroad at Caliente. Disseminated deposits and veinlets in shattered Paleozoic quartzite. The district was discovered in 1892 and yielded largely through 1909. The production was negligible from 1910 to 1932; there has since been a moderate production by lessees. Recorded production, 1902–32, 763,461 tons of ore yielding 186,540.54 oz. Au, 317,100 oz. Ag, 576 lbs. Cu, 7,341 lbs. Pb, valued in all at $4,029,886. The production in 1892–1901, as compiled by Callaghan from records of the county assessor, amounted to 573,207 tons of ore valued at $9,454,034. (See fig. 29.)

●*Freiburg* (*Worthington*).[12]—75 miles from railroad at Pioche. Silver-lead ores in limestone. The district was discovered in 1865, and a small production was made in succeeding years. Small shipments in 1919, 1921, and 1925 amounted to 43 tons, containing lead,

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[9] Lincoln, F. C., op. cit., p. 119. Butler, B. S., Ore deposits of Utah : U. S. Geol. Survey Prof. Paper 111, pp. 563–567, 1920.

[10] Lincoln, F. C., op. cit., pp. 127–128. Westgate, L. G., and Knopf, Adolph, op. cit., pp. 51, 67.

[11] Lincoln, F. C., op. cit., pp. 119–120. Emmons, S. F., The Delamar and Horn Silver mines : Am. Inst. Min. Eng. Trans., vol. 31, pp. 658–675, 1902. Callaghan, Eugene, Geology of the Delamar district, Lincoln County, Nev. : Nevada Univ. Bull. (in preparation).

[12] Lincoln, F. C., op. cit., p. 120.

silver, copper, and gold with a total value of less than $5,000. There appears to have been no recent activity.

● *Groom.*[13]—100 miles from railroad at Las Vegas. Lead ore, with relatively low silver content, replacing limestone and in veins in quartzite. The district was discovered in 1869, but early production was apparently negligible. The district was revived in 1915, and about $400,000 was produced in 1915–19. Since 1922 there has been a fairly regular small production. Almost all the output has come from one mine. Recorded production, 1915–32, 5,995 tons of ore yielding 15.59 oz. Au, 93,957 oz. Ag, 50,162 lbs. Cu, 6,094,908 lbs. Pb, valued in all at $531,222.

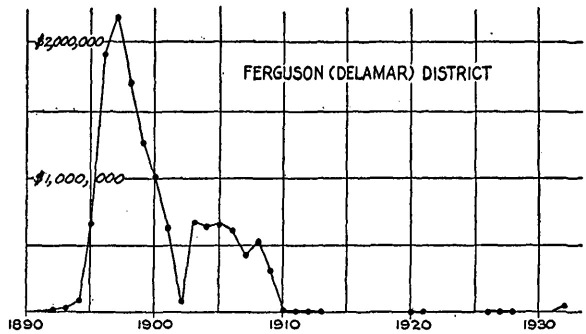

FIGURE 29.—Annual production of nonferrous metals in Ferguson (Delamar) district, Nevada, 1892–1932.

Highland.[14]—8 miles from railroad at Pioche. Lead-silver replacement veins in lower Paleozoic limestone. The district was discovered in 1869 and was actively worked for a few years thereafter. Some production was made, probably less than $50,000 in all. The Mendha mine was active in 1921–24, but little work has been done during the last few years. Recorded production, 1908–32, 2,836 tons of ore yielding 824.04 oz. Au, 31,679 oz. Ag, 2,141 lbs. Cu, 813,331 lbs. Pb, valued in all at $79,813. These figures are incomplete, as part of the production is included in the figures for the Pioche district.

● *Hiko (Pahranagat).*[15]—60 miles from railroad at Caliente. Veins of silver-lead ore in Paleozoic sediments. The district was discovered in 1865 and was the scene of considerable activity until about 1871. Since then there appears to have been very little production. Recorded production, 1915–32, 111 tons of ore containing silver, lead, gold, and copper, valued at $5,207. The earlier production is unknown.

[13] Lincoln, F. C., op. cit., p. 121.
[14] Westgate, L. G., and Knopf, Adolph, op. cit., pp. 73–75.
[15] Lincoln, F. C., op. cit., p. 123.

● *Jackrabbit* (*Bristol*).[16]—On narrow-gage railroad. Oxidized silver-lead-copper replacement deposits in limestone. Oxidized manganese-iron ore has also been produced in the district. The district was organized in 1871 and yielded about $2,000,000 prior to 1900. After 1904 a succession of companies operated the mines until almost all of them were brought under the control of the Bristol Silver Mines Co. A fairly regular output was maintained until the mines were closed in June 1931. Leasing operations continued, and early in 1934 both leasing and company operations were being carried on. Recorded production, 1904–32, 292,876 tons of ore yielding 4,040.83 oz. Au, 3,306,407 oz. Ag, 13,605,261 lbs. Cu, 24,844,628 lbs. Pb, 14,763 lbs. Zn, valued in all at $5,870,437 (fig. 30). These figures are incomplete in that part of the production has been included with that of the Pioche district.

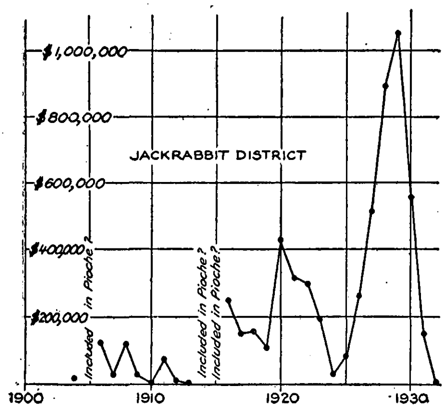

FIGURE 30.—Annual production of nonferrous metals in Jackrabbit district, Nevada, 1904–32.

Patterson (*Cave Valley*, *Geyser*, *Santa Marta*).[17]—50 miles from railroad at Pioche or Ely. Small pockets of silver ore in veins cutting lower Paleozoic sediments. ● The district was discovered in 1869 and was worked for a few years thereafter, but the amount of the probably small production is unknown. The deposits have been worked occasionally in recent years. Recorded production, 1904–32, 1,610 tons of ore yielding 39.82 oz. Au, 25,925 oz. Ag, 490 lbs. Cu, 5,499 lbs. Pb, valued in all at $25,000.

● *Pioche* (*Ely*).[18]—On railroad. Three types of deposits have been mined at Pioche—oxidized ores rich in silver, found in veins in quartzite; lenticular masses of oxidized silver ores in an altered dike; and replacement deposits in limestone, which yield mixed silver-lead-zinc sulphide ores and oxidized iron-manganese ores valuable in the past chiefly for fluxing. The first two classes account for most of the early production of the district, and the last has yielded most of the ore mined in recent years. At least 5,000,000 tons of silver-lead-zinc sulphide ore is reported to have

[16] Lincoln, F. C., op. cit., pp. 121–123. Westgate, L. G., and Knopf, Adolph, op. cit., pp. 67–73.

[17] Lincoln, F. C., op. cit., pp. 123–124. Hill, J. M., Notes on some mining districts of eastern Nevada: U. S. Geol. Survey Bull. 648, pp. 120–124, 1916. Schrader, F. C., Notes on ore deposits at Cave Valley, Patterson district, Lincoln County, Nev.: Nevada Univ. Bull., vol. 25, no. 3, 1931.

[18] Lincoln, F. C., op. cit., pp. 124–127. Westgate, L. G., and Knopf, Adolph, op. cit.

been developed by drilling on the Combined Metals and adjoining properties and is said to be of comparable grade to the material now being mined (7 oz. Ag per ton, 7 percent Pb, 14 percent Zn). The ore is now being shipped to Utah for concentration by flotation, but the company plans to treat the ore locally if a cheap source of power becomes available. Drilling has also disclosed additional reserves of oxidized ore rich in iron and manganese, similar to that mined in the past from the ground of the Prince and Virginia Louise companies. The district was discovered in 1864, but production does not seem to have begun until 1869. In 1870–75 about $16,000,000 was produced from the veins in quartzite. Production thereafter declined rapidly, but a minor peak of production was reached in the early nineties, when the ore in the Yuba dike was exploited. The total production prior to 1902 was probably somewhat less than $20,000,000. Recorded production, 1902–32, 1,603,353 tons of ore yielding 38,777.71 oz. Au, 8,163,171 oz. Ag, 4,023,883 lbs. Cu, 123,583,252 lbs. Pb, 86,510,082 lbs. Zn, valued in all at $20,294,389 (fig. 31). These totals include parts of the production from the Jackrabbit and Highland districts.

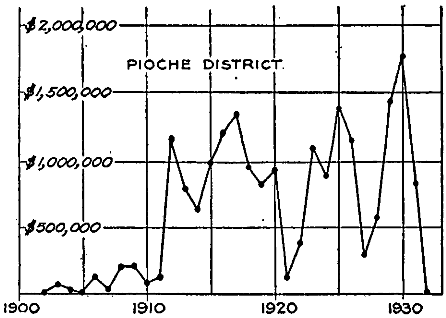

FIGURE 31.—Annual production of nonferrous metals in Pioche district, Nevada, 1902–32.

Tempiute.[19]—75 miles from railroad at Caliente. Silver-rich veins in lower Paleozoic limestone. The district was discovered in the sixties and worked on a rather small scale through the seventies. It appears then to have been inactive until 1924, since when several small shipments have been made. Recorded production, 1924–32, 377 tons of ore yielding 15,469 oz. Ag, 3,718 lbs. Pb, and small amounts of gold and copper, valued in all at $9,375.

Viola.[19]—Close to railroad. Reported to contain veins of copper and lead-zinc ore in limestone. Work in the district was first reported in 1915, and several small shipments of copper and lead-zinc ore have been made. Some activity was reported early in 1934. Recorded production, 1915–32, 100 tons of ore containing silver, copper, zinc, and lead, valued at less than $5,000.

NYE COUNTY

● *Antelope Springs.*[20]—30 miles from railroad at Goldfield. Gold- and silver-bearing quartz veins in locally alunitized Tertiary rhyo-

[19] Lincoln, F. C., op. cit., p. 128.

[20] Idem, p. 158. Schrader, F. C., Notes on the Antelope district, Nev.: U. S. Geol. Survey Bull. 530, pp. 87–98, 1913.

lite. In April 1934 the camp was deserted, and apparently the only activity since 1926 has been annual assessment work. The camp was discovered in 1903 and was the scene of a minor boom in 1911–12. Recorded production, 1903–32, 338 tons of ore yielding 113.63 oz. Au, 43,380 oz. Ag, 627 lbs. Cu, 26,750 lbs. Pb, valued in all at $30,263. Shipments were made in 1912–17 and 1926.

Arrowhead.[21]—65 miles from railroad at Tonopah. Gold- and silver-bearing veins in Tertiary volcanic rocks. Apparently only one mine has been productive, shipping ore to a Tonopah mill in 1920–22. Recorded production, 1920–32, 125 tons of ore containing gold and silver, valued at slightly more than $10,000.

● *Bellehelen* (*Longstreet*).[22]—50 miles from railroad at Tonopah. Gold- and silver-bearing quartz-adularia veins in rhyolite breccia. The district has had several periods of activity, but in 1934 the old Bellehelen mine was closed, and the mill was being dismantled and moved to Goodsprings. Recorded production, 1906–32, including the output of the Clifford district, 8,315 tons of ore yielding 6,683.06 oz. Au, 258,853 oz. Ag, 4,787 lbs. Cu, valued in all at $337,226. The production of the Bellehelen district alone probably amounts to slightly more than $200,000.

● *Bullfrog* (*Pioneer*, *Beatty*, *Rhyolite*).[23]—Railroad terminus at Beatty. The district was discovered in 1904 and contains gold- and silver-bearing veins that follow faults cutting a series of Tertiary volcanic rocks. Recorded production, 1905–32, 288,939 tons of ore yielding 112,627.91 oz. Au, 874,219 oz. Ag, 7,284 lbs. Cu, 17,002 lbs. Pb, valued in all at $2,813,673 (fig. 32). By far the greater part of this output came from the Montgomery Shoshone mine in 1907–10. Near the end of 1910 the mine was closed because of the low grade of the remaining ore. In 1911–16 a reduced output continued, in part from the Pioneer portion of the district to the north. Since the removal of the power line in 1917, the annual output has been $5,000 or less. Activity early in 1934 was confined to minor leasing operations and to the examination of the old Mayflower mine, in the Pioneer section of the district.

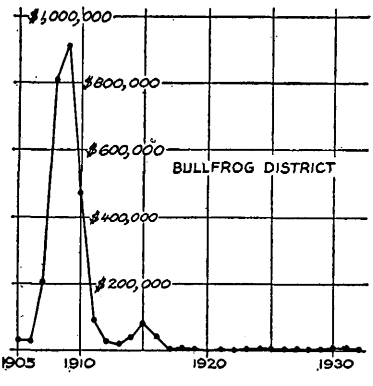

FIGURE 32.—Annual production of nonferrous metals in Bullfrog district, Nevada, 1905–32.

[21] Lincoln, F. C., op. cit., pp. 158–159.
[22] Idem, pp. 160–161.
[23] Idem, pp. 162–163. Ransome, F. L., Emmons, W. H., and Garrey, G. H., Geology and ore deposits of the Bullfrog district, Nev.: U. S. Geol. Survey Bull. 407, 1910.

● *Cactus Springs* (*Cactus Range*).[24]—24 miles from railroad at Goldfield. Gold- and silver-bearing quartz veins, almost all in Tertiary rhyolites. Recorded production, less than $1,000, but it is certain that the true amount is somewhat larger. The district has been extensively prospected, and at least three properties were undergoing development on a small scale early in 1934.

● *Clarkdale.*—30 miles from railroad at Beatty. Gold- and silver-bearing veins in rhyolitic rocks. The district is a relatively recent discovery and the production prior to 1934 consisted of one shipment, valued at less than $1,000, in 1933. There was only minor activity at two properties early in 1934, after the relinquishment by a California group of a lease and bond on one of the mines.

● *Clifford.*[25]—35 miles from railroad at Tonopah. Gold- and silver-bearing ore in tiny pipelike bodies, more or less veined by quartz, in rhyolite tuff and breccia. The production of the district has been included by Heikes and Gerry with that of the Bellehelen district, but the Clifford district alone appears to have made in 1906–32 an output of about $125,000 in gold and silver. The ore mined appears to have come from surface workings, and it is reported that work done in shafts 200 and 300 feet deep failed to disclose ore. The production in recent years has been largely due to lessees.

Currant.[26]—50 miles from railroad at Ely. Ores valuable chiefly for gold and lead. The only shipment recorded from the district was made in 1914 and was valued at $1,600.

● *Eden* (*Eden Creek, Gold Belt*).[27]—60 miles from railroad at Tonopah. Gold- and silver-bearing veins in Tertiary rhyolite. Deposits have been prospected on various occasions since their discovery in 1905, but the recorded production is restricted to small shipments in 1928, 1929, and 1932, valued at $1,262.

● *Ellendale.*[28]—25 miles from railroad at Tonopah. Rich gold ore in silicified rhyolite, especially near andesite porphyry. The district was discovered a short time prior to 1910, and a considerable amount of exploration has been done. In May 1934 the district was deserted. Recorded production, 1910–32, 670 tons of ore yielding 5,119.62 oz. Au, 4,738 oz. Ag, 4,403 lbs. Cu, 861 lbs. Pb, valued in all at $109,966. More than $100,000 of this total was produced prior to 1919. (See p. 150.)

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[24] Lincoln, F. C., op. cit., p. 164. Ball, S. H., op. cit., pp. 89–96.

[25] Lincoln, F. C., op. cit., p. 165. Ferguson, H. G., The Golden Arrow, Clifford, and Ellendale districts, Nye County, Nev.; U. S. Geol. Survey Bull. 640, pp. 113–123, 1916.

[26] Lincoln, F. C., op. cit., p. 166.

[27] Idem, p. 166. Ball, S. H., op. cit., pp. 110–111.

[28] Lincoln, F. C., op. cit., p. 167. Ferguson, H. G., op. cit., pp. 113–123.

● *Fluorine* (*Bare Mountain*, *Telluride*).[29]—Railroad at Beatty and Carrara. The gold deposits in this district are of several kinds, but the most productive ones are found in lower Paleozoic limestone or dolomite, with very little introduced quartz. Several properties have recently been active, and one of these was milling a low-grade ore early in 1934. Small rich pockets have been found in several places, but the ores on the whole are of low grade. Recorded production, 1913–32, 5,718 tons of ore yielding 1,263.62 oz. Au, 391 oz. Ag, 66 lbs. Cu, 489 lbs. Pb, valued in all at $26,372. Production prior to 1913 is included in that given for the Bullfrog district. (See p. 172.)

● *Gold Crater*.[30]—27 miles from railroad at Goldfield. Gold- and silver-bearing lodes and disseminated deposits in altered andesite. The camp was discovered in 1904. The only production recorded was made in 1916 and consisted of 120 tons of ore, valued at $2,015. In April 1934 one man was leasing.

● *Golden Arrow* (*Blakes Camp*).[31]—50 miles from railroad at Tonopah. Gold- and silver-bearing deposits in Tertiary andesite and rhyolite. The district was discovered in 1905, but the only shipments recorded up to 1932 were made in 1915 and 1916 and had a value of $1,527. The district was reported to be deserted in May 1934.

● *Gold Range*.—100 miles from railroad at Tonopah. Gold-bearing veins in rhyolite. The district was the site of a minor boom several years ago, and a moderate amount of exploratory work was done. There is no recorded production from the district, but some prospecting is now being carried on.

● *Hannapah* (*Silverzone*, *Volcano*).[32]—18 miles from railroad at Tonopah. Gold- and silver-bearing veins in rhyolite flows and pyroclastic rocks. The district was discovered in 1902 and has been the scene of several minor booms. Recorded production, 1908–32, 704 tons of ore yielding 192.10 oz. Au and 41,081 oz. Ag, valued in all at $29,678. In May 1934 two properties were being worked by lessees, and at a third a 300-foot shaft was being unwatered preparatory to further exploration.

● *Johnnie*.[33]—25 miles from railroad at Death Valley Junction, Calif. Gold-bearing veins in lower Paleozoic sediments. The district was discovered in 1892 and is reported to have produced about

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[29] Lincoln, F. C., op. cit., pp. 167–169. Ball, S. H., op. cit., pp. 153–157.

[30] Lincoln, F. C., op. cit., p. 169. Ball, S. H., op. cit., pp. 131–137, 139–140.

[31] Lincoln, F. C., op. cit., pp. 169–170. Ball, S. H., op. cit., p. 110. Ferguson, H. G., op. cit., pp. 113–123.

[32] Lincoln, F. C., op. cit., p. 170.

[33] Lincoln, F. C., op. cit., pp. 172–173. Nolan, T. B., Geology of the northwest portion of the Spring Mountains, Nev. (thesis, Yale University), 1924.

$500,000 prior to 1904. A considerable amount of development work has been done, and the incline at the Johnnie mine is 1,000 feet deep. Recorded production, 1908–32, 88,846 tons of ore yielding 24,652.99 oz. Au, 3,645 oz. Ag, 6,017 lbs. Pb, valued in all at $503,320. About four-fifths of this amount was produced prior to 1914, chiefly from the Johnnie mine, which has, however, continued to yield a small output annually. About 10 or 12 men were working in the district in May 1934.

Kawich (*Gold Reed*).[34]—54 miles from railroad at Goldfield. Gold deposits in altered monzonite porphyry. The district was discovered in 1904. Recorded production, 1921 and 1927, $3,868. There was no activity in the district early in 1934.

Morey.[35]—80 miles from railroad at Tonopah. Silver-rich veins in granite. The district was discovered in 1866 and worked actively until about 1876. Recorded production since 1904, small shipments of silver-lead-gold ore in 1921–22, valued at $4,187.

● *Oak Springs*.[36]—90 miles from railroad at Caliente or Beatty. Veins in Paleozoic sediments and granitic rocks. There has been considerable scattered prospecting, but the only recorded production was made in 1917, when 18 tons of copper ore, valued at $1,099, was shipped.

● *Quartz Mountain*.—14 miles from railroad at Goldfield. Gold-bearing veins in silicified lake beds and tuff. No production recorded, but a fair amount of exploratory work has been done.

Reveille.[37]—70 miles from railroad at Tonopah. Silver- and lead-bearing veins in Paleozoic sedimentary rocks. The district was discovered in 1866 and was active until about 1880. Interest in it was revived about 1904, and since then there has been a sporadic output. Recorded production, 1904–32, 2,500 tons of ore yielding 116.70 oz. Au, 101,071 oz. Ag, 8,075 lbs. Cu, 917,490 lbs. Pb, valued in all at $133,708. The average annual output for the 17 years in which shipments have been made is about 150 tons.

● *Silver Bow*.[38]—45 miles from railroad at Goldfield. Silver- and gold-bearing veins in rhyolite. The district was discovered in 1905 and made small shipments of rich ore from 1906 to 1914. Attempts were made to mill the ore on three occasions, but none appear to have been financially successful. There has been a rather regular small output since 1929 by lessees. Recorded production, 1907–32, 1,672 tons of ore yielding 976.45 oz. Au and 57,770 ounces Ag, valued in all at $51,705.

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[34] Lincoln, F. C., op. cit., p. 173. Ball, S. H., op. cit., pp. 108–113.
[35] Lincoln, F. C., op. cit., p. 178.
[36] Idem, pp. 178–179. Ball, S. H., op. cit., pp. 118–130.
[37] Lincoln, F. C., op. cit., pp. 179–180. Ball, S. H., op. cit., pp. 114–117.
[38] Lincoln, F. C., op. cit., pp. 182–183. Ball, S. H., op. cit., pp. 109–110.

● *Stonewall Mountain.*[39]—17 miles from railroad at Goldfield. Silver- and gold-bearing veins in granitic and sedimentary rocks. The district was discovered in 1905. Small shipments were made in 1911, 1915, and 1916, having a gross value of somewhat more than $1,000.

● *Tolicha (Monte Cristo).*[40]—32 miles from railroad at Beatty. Largely gold- and silver-bearing veins in rhyolite. The district was discovered in 1905, but there was little activity until about 1917, when some rich ore was discovered. A minor boom resulted from another discovery in 1923. Since 1928 there has been a small annual production from lessees' operations. Recorded production, 1909–32, 342 tons of ore yielding 458.21 oz. Au, 1,236 oz. Ag, 11,392 lbs. Cu, 1,778 lbs. Pb, valued in all at $11,774.

● *Tonopah.*[41]—On railroad. Silver- and gold-bearing veins in a series of volcanic rocks, which are in large part bedded. The district was discovered in 1900 and reached its peak production of more than $9,000,000 in 1913. The high price of silver during the war, continued by the Pittman Act, resulted in the maintenance of an annual production between $5,000,000 and $7,000,000 for 10 years, in spite of the gradual exhaustion of the high-grade ores and a series of costly strikes. On the expiration of the Pittman Act, however, the production dropped notably, and the subsequent gradual decline in the price of silver has been reflected in the district output (fig. 33). Since 1931 the production has been derived in large part from lessees' operations. Recorded production, 1900–32: 8,262,944 tons of ore yielding 1,790,961.24 oz. Au, 168,525,219 oz. Ag, 7,949 lbs. Cu, 19,404 lbs. Pb, valued in all at $148,026,139. It is possible that continued high prices for silver may promote exploration for additional ore bodies in geologically favorable parts of the district. All ore pro-

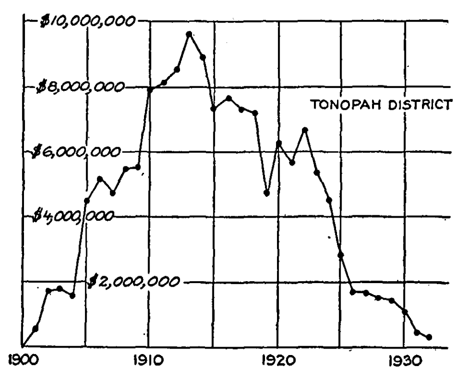

FIGURE 33.—Annual production of nonferrous metals in Tonopah district, Nevada, 1900–32.

[39] Lincoln, F. C., op. cit., p. 183. Ball, S. H., op. cit., pp. 83–89.

[40] Lincoln, F. C., op. cit., pp. 183–184. Ball, S. H., op. cit., pp. 141–142.

[41] Lincoln, F. C., op. cit., pp. 184–193. Spurr, J. E., Geology of the Tonopah mining district, Nev.: U. S. Geol. Survey Prof. Paper 42, 1905; Ore deposition at Tonopah, Nev.: Econ. Geology, vol. 10, pp. 713–769, 1915. Burgess, J. A., The geology of the producing part of the Tonopah mining district: Econ. Geology, vol. 4, pp. 681–712, 1909. Locke, Augustus, The geology of the Tonopah mining district: Am. Inst. Min. Eng. Trans., vol. 43, pp. 157–166, 1912. Bastin, E. S., and Laney, F. B., The genesis of the ores at Tonopah, Nev.: U. S. Geol. Survey Prof. Paper 104, 1918. Nolan, T. B., The underground geology of the Tonopah mining district, Nev.: Nevada Univ. Bull., vol. 29, no. 5, 1935.

duced at the present time must be of shipping grade, but there are two mills in the district in which lower-grade ores might be treated.

Trappmans.[42]—40 miles from railroad at Goldfield. Silver- and gold-bearing veins in granite. The district was discovered in 1904. The only recorded production was made in 1908 and consisted of a small lot of ore valued at less than $200. The district has been essentially abandoned for many years.

Troy (*Irwin Canyon, Nyala*).[43]—80 miles from railroad at Ely. Quartz veins and lenses in shaly limestone near its contact with quartz monzonite. The district was discovered in 1867, and close to $500,000 was spent in developing the ore bodies, but the early production appears to have been relatively small. Recorded production, 1916, 1925–26, and 1928, 27 tons of ore containing lead and silver, valued at $2,207.

● *Tybo* (*Hot Creek, Keystone*).[44]—68 miles from railroad at Tonopah. Argentiferous lead-zinc tabular replacement bodies in a granitic dike that follows a fault. The Hot Creek section was discovered in 1865, but became inactive about 1870; the Tybo section was discovered in 1870 and produced about $3,000,000 in silver, lead, and gold prior to 1888. The Tybo mine was taken over by the Treadwell-Yukon Co. in 1925, after unsuccessful attempts to work the property in 1901, 1906, and 1917. Production by this company started in 1929, and lead and zinc concentrates were hauled by truck to Tonopah. The mine was closed from October 1931 to early in 1934, when operations were resumed. In May 1934, 60 tons of concentrates were being shipped daily. At the end of 1931 ore reserves were reported to be 163,000 tons with an average content of 0.03 ounce of gold and 12.5 ounces of silver to the ton, 7.5 percent of lead, and 5.25 percent of zinc. Recorded production, 1902–32, 211,756 tons of ore yielding 3,552.14 oz. Au, 1,668,894 oz. Ag, 33,986 lbs. Cu, 20,828,783 lbs. Pb, 12,678,846 lbs. Zn, valued in all at $2,375,000. Over 90 percent of this total was produced in 1929–31.

● *Wahmonie.*—60 miles by road from railroad at Beatty. Silver-gold ore in silicified shear zones cutting altered porphyry. The Horn Silver mine was prospected prior to 1905, but the district was rediscovered in 1928, when a minor boom ensued. It is now abandoned. No production is recorded by Heikes and Gerry, but some shipments may have been made.

Wellington (*Jamestown, O'Briens*).[45]—45 miles from railroad at Goldfield. Gold-silver ore from veins in Tertiary volcanic rocks.

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[42] Lincoln, F. C., op. cit., p. 193. Ball, S. H., op. cit., pp. 131–139.

[43] Lincoln, F. C., op. cit., pp. 193–194. Hill, J. M., Notes on some mining districts in eastern Nevada: U. S. Geol. Survey Bull. 648, pp. 138–144, 1916.

[44] Lincoln, F. C., op. cit., p. 195. Ferguson, H. G., Geology of the Tybo district, Nev.: Nevada Univ. Bull., vol. 27, no. 3, 1933.

[45] Lincoln, F. C., op. cit., pp. 197–198. Ball, S. H., op. cit., p. 95.

The district was discovered in 1904 and has been only sporadically active since that time. One property was being prospected in April 1934. No production is recorded by Heikes and Gerry, but small shipments are said to have been made.

Willow Creek.[46]—90 miles from railroad at Ely or Tonopah. Gold-quartz veins and bedded silver-rich replacement bodies in sedimentary rocks near quartz monzonite contact. The district was discovered in 1911 and has yielded small shipments of ore rather regularly since 1913. Recorded production, 243 tons of ore valued at $10,945, chiefly in gold and silver with a little lead.

Wilsons.[47]—40 miles from railroad at Goldfield. Silver-gold veins in Tertiary volcanic rocks. The district was discovered in 1904 but has been inactive for many years. There is no recorded production.

UTAH

BEAVER COUNTY

Beaver Lake.[48]—2 to 5 miles from railroad at Solus siding. Copper-bearing quartz veins in quartz monzonite; contact deposits in limestone. The district was organized in 1871, and some copper and silver-lead ore was shipped. Since 1900 the district has produced during periods of high copper prices; little or no work was being done early in 1934. Recorded production, 1911–32, 1,530 tons of ore yielding 24.08 oz. Au, 2,208 oz. Ag, 171,130 lbs. Cu, 44,868 lbs. Pb, valued in all at $45,381. The production in 1902–10 was small and is included with that of the Rocky district; that prior to 1902 amounted to about $100,000, chiefly from copper ore.

Bradshaw.[49]—10 miles from railroad at Milford. Oxidized replacement deposits and contact deposits in limestone. The region was first prospected in 1859, but little work was done prior to organization of the district in 1876. The production prior to 1902 was probably about $300,000 in silver, gold, and lead. There was only minor activity early in 1934. Recorded production, 1902–32, 1,671 tons of ore yielding 249.60 oz. Au, 3,739 oz. Ag, 11,690 lbs. Cu, 79,908 lbs. Pb, valued in all at $12,823.

Granite and North Granite.[49]—25 miles from railroad at Milford. Veins and contact deposits containing copper, lead, zinc, silver, and bismuth, in limestone near granite contact. The districts were organized in 1863 and 1865. Some shipments were made prior to 1902, but they probably amounted to less than $50,000. Other ship-

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[46] Lincoln, F. C., op. cit., p. 198. Hill, J. M., op. cit., pp. 144–151.

[47] Lincoln, F. C., op. cit., p. 198. Ball, S. H., op. cit., p. 139.

[48] Butler, B. S., and others, Ore deposits of Utah: U. S. Geol. Survey Prof. Paper 111, pp. 505–527, 1920. Butler, B. S., Geology and ore deposits of the San Francisco and adjacent districts, Utah: U. S. Geol. Survey Prof. Paper 80, pp. 189–193, 1913.

[49] Butler, B. S., and others, op. cit., pp. 530–536.

ments were made in 1916, 1917, and 1922. There appears to have been no activity in recent years. Recorded production, 1911–32, 612 tons of ore yielding 7.85 oz. Au, 1,577 oz. Ag, 24,865 lbs. Cu, 58,372 lbs. Pb, 51,000 lbs. Zn, valued in all at $18,439.

Indian Peak.[50]—45 miles from railroad at Lund. Lead-silver replacement deposits in limestone. Although some small shipments have been reported from the district, no production is recorded and there appears to have been no activity in recent years.

Lincoln (Jarloose).[51]—20 miles from railroad at Milford. Silver-lead-zinc replacement deposits in limestone; gold-silver veins in volcanic rocks. The first lead produced in the West is said to have come from the Rollins mine in this district, which was discovered about 1854. The mine was worked on several occasions prior to 1902, but the production during this period was probably not much more than $100,000. The district was again active in 1913–19 and 1923–27, but there seems to have been no activity recently. Recorded production, 1910–32, 8,728 tons of ore yielding 711.93 oz. Au, 40,053 oz. Ag, 387,708 lbs. Cu, 488,537 lbs. Pb, 58,506 lbs. Zn, valued in all at $179,598.

McGarry and Antelope.[51]—North of the Bradshaw district, 10 to 15 miles from railroad at Milford. These districts were organized in 1876 and 1877 but have yielded only a very small production. There is no recorded output since 1902, and there appears to have been no activity in the districts in recent years.

Pine Grove.[52]—18 miles from railroad at Newhouse. Lead-silver veins in Paleozoic sedimentary rocks. The district was organized in 1873 but yielded little ore prior to 1902. Shipments were made in 1919–20 amounting to 73 tons of lead-silver ore with a little copper and gold, valued at less than $5,000. There appears to have been no activity in recent years.

Preuss (Newhouse).[53]—Terminus of branch railroad. Copper deposits in monzonite; lead-silver deposits in limestone. The district was discovered early and reorganized in 1880. The copper deposits were explored on several occasions but made only a minor production prior to 1905. The Cactus mine was active in 1905–14, and the tailings from the mine were reworked in 1915–19. Numerous small shipments of lead-silver ore were recorded up to 1925. There has been no recent activity in the district. The bulk of the production, including that of the Cactus mine, the largest producer, has been included in the figures for the San Francisco district and

[50] Butler, B. S., and others, op. cit., pp. 527–529.

[51] Idem, pp. 529–536.

[52] Idem, pp. 527–529.

[53] Idem, pp. 503–527. Butler, B. S., Geology and ore deposits of the San Francisco and adjacent districts, Utah: U. S. Geol. Survey Prof. Paper 80, pp. 172–189, 1913.

appears to be about $5,000,000, largely in copper. Recorded production, 1911–32, 895 tons of ore yielding 15.28 oz. Au, 7,327 oz. Ag, 24,747 lbs. Cu, 225,955 lbs. Pb, valued in all at $23,545.

Rocky.[54]—1 mile from railroad at Hickory. Contact copper deposits in sediments adjacent to intrusive quartz monzonite. The district was organized in 1872 but yielded only a small tonnage of ore prior to 1902. Since then shipments of copper ore have been made in 1906–7, 1912–18, and one small lot in 1929. There has been no recent activity. Recorded production, 1902–32, 122,433 tons of ore yielding 430.41 oz. Au, 90,347 oz. Ag, 5,900,653 lbs. Cu, valued in all at $1,345,058. These figures include a small production from the Beaver Lake district in 1902–10.

San Francisco (*Frisco*).[55]—On branch railroad. Silver-lead-zinc-copper replacement ore bodies, the largest of which, in the Horn Silver mine, is localized by a fault between limestone and volcanic rocks. The district was discovered in 1875 and yielded a rather regular production (chiefly from the Horn Silver mine) up to 1931.

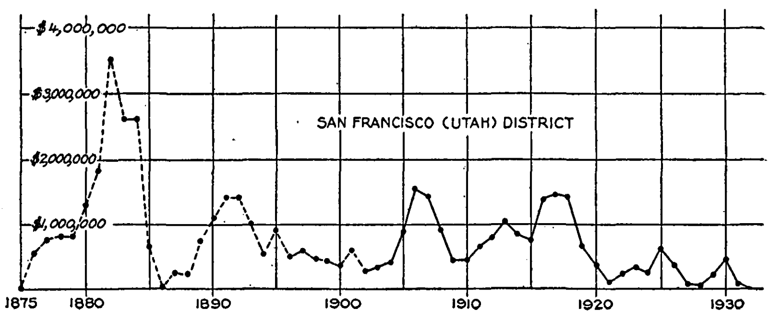

FIGURE 34.—Annual production of nonferrous metals in San Francisco district, Utah, 1875–1932.

The output from 1922 to 1928 was made largely by lessees. Much of the ore was oxidized, but sulphide ore was mined on the lower levels. The old Horn Silver mine is reported to be nearly exhausted, the remaining ore on the lower levels being of low grade, but the company has plans for development work in the limestone footwall. The district has been inactive since 1931. Recorded production, 1902–32, 2,777,090 tons of ore yielding 29,451.78 oz. Au, 4,792,022 oz. Ag, 40,301,385 lbs. Cu, 105,373,920 lbs. Pb, 36,817,641 lbs. Zn, valued in all at $19,113,053. This includes most of the production of the Preuss district. The total production, 1875–1932, has been estimated at 32,997 oz. Au, 18,510,300 oz. Ag, 44,628,432 lbs. Cu, 395,414,884 lbs. Pb, 36,817,641 lbs. Zn, valued at $39,255,532 (fig. 34).

[54] Butler, B. S., and others, op. cit., pp. 503–527. Butler, B. S., op. cit., pp. 117–118, 193–194.

[55] Butler, B. S., and others, op. cit., pp. 503–527. Butler, B. S., op. cit.

● *Star and North Star.*[56]—5 to 15 miles from railroad at Milford. Silver-lead-copper-zinc replacement bodies in limestone. The ore shipped has been largely oxidized. The districts were organized in 1870 and 1871 and yielded considerable ore in the next few years. They were revived about 1904 and since then have made a steady small production from several properties, among which the Moscow mine has been the most productive. There was only minor activity in the region early in 1934. Recorded production, 1902–32, 92,065 tons of ore yielding 2,511.40 oz. Au, 1,127,854 oz. Ag, 1,676,565 lbs. Cu, 33,092,748 lbs. Pb, 1,499,539 lbs. Zn, valued in all at $2,967,736 (fig. 35). The production prior to 1902 has been estimated at $1,100,000.

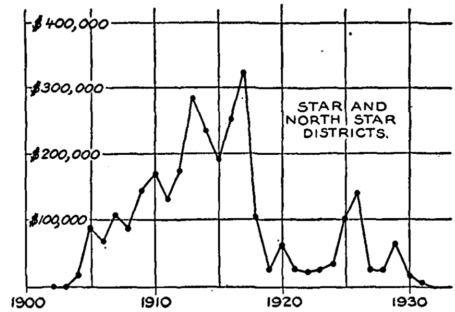

FIGURE 35.—Annual production of nonferrous metals in Star and North Star districts, Utah, 1902–32.

Washington.—50 miles from railroad at Lund. Probably replacement deposits in limestone. Small shipments of ore containing gold, silver, copper, and lead, valued at less than $1,000, are recorded from the district, which may be coextensive in part with the Indian Peak district.

IRON COUNTY

Calumet.—28 miles from railroad at Sahara. Lead-bearing lode in limestone. Shipments of lead ore, containing also very small amounts of gold, silver, and copper, were made in 1916–17 and 1923–25. There appears to have been no recent activity. The 743 tons of ore shipped yielded 319,481 lbs. Pb and was valued at $25,679.

Gold Springs.[57]—17 miles from railroad at Modena. Gold- and silver-bearing veins in Tertiary volcanic rocks. The district was discovered about 1896 and was active for a few years thereafter. Recorded production, 1907–15, 12,939 tons of ore yielding 2,482.49 oz. Au, and 8,962 oz. Ag, valued at $56,364. The district appears to have been inactive from 1915 up to about 1933. Early in 1934 there was considerable activity in the region, and one company was milling 40 tons of ore daily. The production prior to 1907 is unknown.

● *Stateline.*[57]—17 miles from railroad at Modena. Gold- and silver-bearing veins in Tertiary volcanic rocks. The silver content is

[56] Butler, B. S., and others, op. cit., pp. 503–527. Butler, B. S., op. cit., pp. 114–116, 194–206.

[57] Butler, B. S., and others, op. cit., pp. 563–568.

relatively higher than in the similar Gold Springs veins. The district was discovered in 1896, and considerable ore was milled prior to 1902, although the exact amount is unknown. The district has been sporadically active since that time, especially in the last few years. Recorded production, 1902–32, 13,038 tons of ore yielding 2,540.48 oz. Au. 91,348 oz. Ag. 1,584 lbs. Cu, 77,260 lbs. Pb, valued in all at $105,220.

WASHINGTON COUNTY

Bull Valley (*Goldstrike*).[58]—28 miles from railroad at Modena. Gold-bearing veins in sedimentary rocks, though possibly related genetically to Tertiary volcanic rocks. The district was discovered about 1907, but the first production of any account was made in 1915. Since then there have been several very small shipments of gold, recovered from small pockets. Recorded production, 1915–32, 215 tons of ore yielding 679.90 oz. Au, 253 oz. Ag, 1,066 lbs. Cu, valued in all at $14,479.

Santa Clara.[59]—60 miles from railroad at Cedar City. Silver-bearing sandstone beds. The district was organized in 1880. The sandstone beds, which are the extensions of those found in the Silver Reef district, have been prospected, but, so far as known, no ore has been mined.

Silver Reef (*Harrisburg*, *Leeds*).[60]—40 miles from railroad at Cedar City. Silver-bearing sandstone beds. The district was discovered in 1869 but was not actively worked until 1874. From then until 1889 there was a considerable production. Since 1890, however, the production has been sporadic and small, in large part from lessees' operations. The American Smelting & Refining Co. explored the district in 1928–29 but failed to find sufficient ore to warrant further work. Recorded production, 1902–32, 2,219 tons of ore yielding 0.89 oz. Au, 96,858 oz. Ag, 13,360 lbs. Cu, valued in all at $58,461. The production prior to 1902 was 7,115,721 oz. Ag, valued at $7,933,148, the total yield from the district thus being very close to $8,000,000.

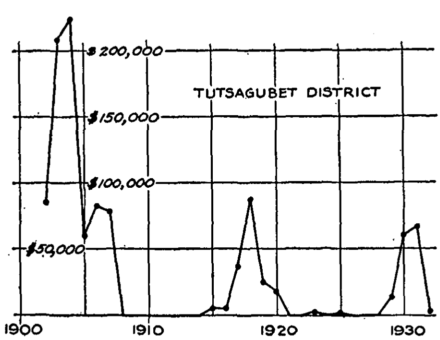

FIGURE 36.—Annual production of nonferrous metals in Tutsagubet district, Utah, 1902–32.

Tutsagubet.[61]—70 miles from railroad at Cedar City. Oxidized copper replacement bodies in limestone. The ore deposits were known prior to 1872, but the district was not organized until 1883. It was worked on a rather small scale in

[58] Butler, B. S., and others, op. cit., pp. 597–598.
[59] Idem, p. 594.
[60] Idem, pp. 582–594.
[61] Idem, pp. 594–597.

1884–93, but the bulk of the production was made in 1899–1906. Since 1906 lessees have shipped ore during periods of high copper prices. Recorded production, 1902–32, 26,018 tons of ore yielding 2.48 oz. Au, 35,020 oz. Ag, 7,151,135 lbs. Cu, 28,118 lbs. Pb, valued in all at $1,072,080 (fig. 36). The production prior to 1902 has been estimated at 110,910 oz. Ag, 5,337,785 lbs. Cu, 43,669 lbs. Pb, valued at $835,783.

FERROUS-METAL DEPOSITS

By D. F. Hewett

IRON ORE

ARIZONA

COCONINO COUNTY

● *Seligman.*—The McBride claims, which lie 17 miles south of Seligman, cover bodies of high-grade hematite at the contact of limestone and diorite. They have been explored in a small way, but no ore has been shipped, and the reserve appears small.

YAVAPAI COUNTY

If the United Verde Copper Co. should carry out some tentative plans to recover most of the elements in the large bodies of mixed sulphide ore at Jerome, iron oxide or metal would be recovered in large quantities.

CALIFORNIA

INYO COUNTY

Iron-ore deposits that carry small amounts of gold and copper are reported in the Coso district, near Darwin, and 7 miles east of Kearsarge. They have been explored in a small way, but the extent of the reserves is not recorded.

RIVERSIDE COUNTY

● *Eagle Mountains.*—The largest quantity of high-grade iron ore known in one locality in the Southwest is found in the Eagle Mountains, 44 miles by road northeast of Mecca, on the Southern Pacific Railroad. The separate masses are roughly tabular and form a belt about 6 miles long in an inaccessible part of the Mojave Desert. Most of the masses are largely black hematite, but some contain a little magnetite. These minerals replace highly inclined dolomite beds of pre-Cambrian age near the contact with intrusive masses. The bodies have been extensively explored by short tunnels and shallow shafts, and many samples have been analyzed. This work indicates a total reserve to 50 feet in depth of about 12,000,000 tons containing 64 percent of iron, 0.03 percent of phosphorus, and 3.2 percent of silica. Earlier published estimates indicated the presence of about 60,000,000 tons to an assumed depth of 200 feet.

Small bodies of similar ore that occurs in similar geologic surroundings are found on the O'Connor claims, on the southern slope of the Palen Mountains 40 miles west of Blythe.

SAN BERNARDINO COUNTY

● *Kingston Mountains.*—Lenses of mixed magnetite and red hematite form a belt about a mile long that extends along the north wall of a canyon which cuts across the Kingston Mountains, 18 miles east of Tecopa. These bodies replace a steeply inclined limestone bed that is part of the pre-Cambrian rocks. Recently the lenses were explored by 12 diamond-drill holes, and a reserve estimated at about 12,000,000 tons of good-grade bessemer ore was determined.

● *Iron Mountain.*—At a point near the divide on the Silver Lake-Cave Springs Road, 12 miles west of Silver Lake, numerous pits have been sunk to explore an uncommon occurrence of iron ore. The iron minerals, largely magnetite, form angular blocks as much as 6 feet long, which are strewn irregularly over two areas of about 5 acres each on a gently dipping alluvial slope. The underlying material comprises sand and gravel of middle Tertiary age, which are certainly not the source of the iron masses. Probably their source is the granite gneiss that forms that part of the Avawatz Mountains which lies to the south. A reserve of several million tons of high-grade iron ore is indicated.

● *Cave Canyon.*—The low hills that lie half a mile north of Baxter on the Union Pacific Railroad contain two belts of iron ore that trend east, parallel to the railroad. These hills are made up of greenish igneous rocks which adjoin a southern belt of limestone that has been exploited for many years (p. 163). The iron minerals, hematite and magnetite, form irregular lenses in the igneous rock. A tunnel, which has been driven 420 feet into the hill 80 feet below the crest, where a large lens of iron ore crops out, cuts the lens, but it is much smaller than on the surface. Estimates of the reserves in the entire area range as high as 20,000,000 tons, but it would appear that 3,000,000 to 5,000,000 tons is a more reliable estimate.

Meir.—The Meir claims, several miles northwest of the Cave Canyon area and north of the Arrowhead Highway, cover small bodies of magnetite.

● *Specular.*—The Specular claim, 3 miles northwest of Kelso, covers a vein of specular hematite in Cambrian dolomite. A shipment of 200 tons of ore during the war is reported, but the reserve is small.

Vulcan.—The Vulcan claims cover one large body of iron minerals, 350 by 750 feet, and several smaller bodies near Foshay Pass, 9 miles southeast of Kelso. The minerals are largely hematite with minor limonite, which replace dolomite near intrusive monzonite. The principal body, explored to a depth of 80 feet, is estimated to contain at least 1,000,000 tons of 60 to 64 percent iron ore and may contain 5,000,000 tons or more.

Cornfield Spring.—A body of specular hematite having the same associations as those at the Vulcan deposit lies about 3 miles northeast of it. On the surface cropping the body is 15 by 40 feet, but it has been cut at a depth of 175 feet in a 600-foot crosscut tunnel. A reserve of several hundred thousand tons of ore containing 60 percent of iron and 0.02 percent of phosphorus is indicated.

Ord Mountains.—Two lenses of hematite and magnetite lie at the contact of granitic rock and dolomite on a ridge that forms the southeastern extension of the Ord Mountains, 18 miles southeast of Newberry, on the Atchison, Topeka & Santa Fe Railway. Estimates of the reserve range as high as 12,000,000 tons of ore containing 65 percent of iron and 0.045 percent of phosphorus.

Iron Hat (Ironclad).—The Iron Hat group of seven claims, in the Marble Mountains, 14 miles east of Amboy, covers tabular bodies of hematite and magnetite that lie at the contact of intrusive rocks and limestone. The bodies attain a maximum width of 40 to 50 feet, but the length is not proved. During recent years about 2,000 tons of ore containing 65 percent iron was mined and shipped to Los Angeles.

Ship Mountains.—A group of seven claims in the Ship Mountains, about 2½ miles south of Siam, covers a zone of hematite bodies that follow the contact of greenstone intrusive and dolomite. The extent of the bodies is obscure, but an inclined shaft explores the zone to a depth of 500 feet. In recent years about 1,000 tons of 60 percent iron ore was mined from this shaft and shipped to Los Angeles.

Iron Age.—Veins of hematite and magnetite in granite are found in the mountains 6 miles east of Dale, 45 miles south of Amboy. The largest is about 425 feet long and 15 to 100 feet wide. There has been little development.

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UTAH

IRON COUNTY

●*Iron Springs.*—Large bodies of magnetite and hematite are known in three parts of the Iron Springs district and have been extensively explored in two of these, the Granite Mountain area and the Iron Mountain area, which are about 10 miles apart. In both areas the iron minerals form large bodies at or near the contact of coarse-grained intrusive rocks and the surrounding sediments. The Desert Mound deposit, in the Granite Mountain area, has been actively exploited since 1926, and about 1,900,000 tons of ore containing 52 percent of iron, 6.5 percent of silica, and 0.20 percent of phosphorus has been shipped to the Columbia Steel Co. at Provo, where it has been smelted to pig iron. At present there are two openings at the east and west ends of a low hill, the larger 200 by 700 by 65 feet deep and the smaller 220 by 400 by 60 feet deep. Estimates of the reserves in the two areas to the depth of drilling range from 15,000,000 to 40,000,000 tons.

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Leith, C. K., and Harder, E. C., Iron ores of the Iron Springs district: U. S. Geol. Survey Bull. 338, 102 pp., 1908.

SUMMARY

The record of iron-ore deposits within 200 miles of the Boulder Dam shows that there is an abundance of high-grade ore. Four of these deposits lie either on or near existing railroads and have already shipped ore. Of these, the deposits at Desert Mound, in the Iron Springs district, 235 miles by rail from Las Vegas, are thoroughly equipped to produce and can supply any prospective demand at once.

MANGANESE

ARIZONA

MARICOPA COUNTY

●*Aguila.*—This district includes two groups of claims—(1) the Armour, U. S., Pittsburg, Gallagher & Flynn, Gilbin, Uhlik & Cuendet, and Sisson & Pegram claims, which lie 14 to 16 miles south of Aguila; (2) the Manganese Development, Atkins, Wheeler, Fugatt, and Meadows claims, which lie 4 miles northeast of the first group.

The Hatton claims, 9 miles northwest of Aguila, are in Yavapai County.

The deposits on these claims display differences in shape, size, and attitude but are similar in geologic essentials. Most of them are simple tabular bodies of high-grade oxides from 2 to 10 feet wide and 100 feet or less in length, that follow steeply inclined fracture zones in volcanic flows or in the underlying crystalline rocks. With exploration in depth, the oxides disappear and are replaced by black manganiferous calcite. The total yield from the seven principal groups of claims is about 4,000 tons of good-grade ore, and the largest yield from one group is 1,500 tons.

If a nearby market were created, there would be a small output, but there seems to be no chance to develop a large resource.

MOHAVE COUNTY

●*Artillery Peak.*[62]—Large deposits of low-grade manganese ore about 6 miles northwest of Alamo crossing on the Williams River and 5 miles southwest of Artillery Peak were explored during the World War. Recently two concerns, the Chapin Exploration Co., of Duluth, Minn., and the Arizona Manganese Corporation, have done considerable exploration and have revealed large reserves of stratified material, most of which contains from 5 to 15 percent of manganese. The most convenient approach to the area is by way of Congress Junction, which is about 45 miles due east of Alamo, but a poor road also extends from Signal, 16 miles north.

Within the area covered by figure 37 manganese oxides occur rather widely in relations of two general types. In four rather definite areas beds of low-grade manganese oxide are found, as described below.

1. On both sides of a deep canyon that trends eastward in secs. 30 and 31, T. 12 N., R. 12 W., covered by a part of the Maggie claims, a bed of manganese-bearing tuffs 20 to 22 feet thick crops out for a distance of at least 1,500 feet. Grab samples on the surface yield as high as 17.7 percent of manganese, and the average of 36 samples from a tunnel 200 feet long is reported to be 16 percent. The areal extent of the bed is not yet proved, but private engineers estimate that 165 acres is underlain by about 14,000,000 tons of material which contains about 13 percent of manganese.

2. In secs. 32 and 33, T. 12 N., R. 12 W., covered by the Chapin claims, a zone of manganese-bearing latite tuff crops out for several thousand feet on the northeast slope of a prominent mesa and has been extensively explored by trenches, tunnels, and shafts. At the

[62] This summary is based on an examination of one week in October 1931, by B. N. Webber, geologist, of Phoenix, Ariz., and D. F. Hewett. The Chapin Exploration Co. and Arizona Manganese Corporation have kindly given access to numerous reports and maps based on studies of the area.

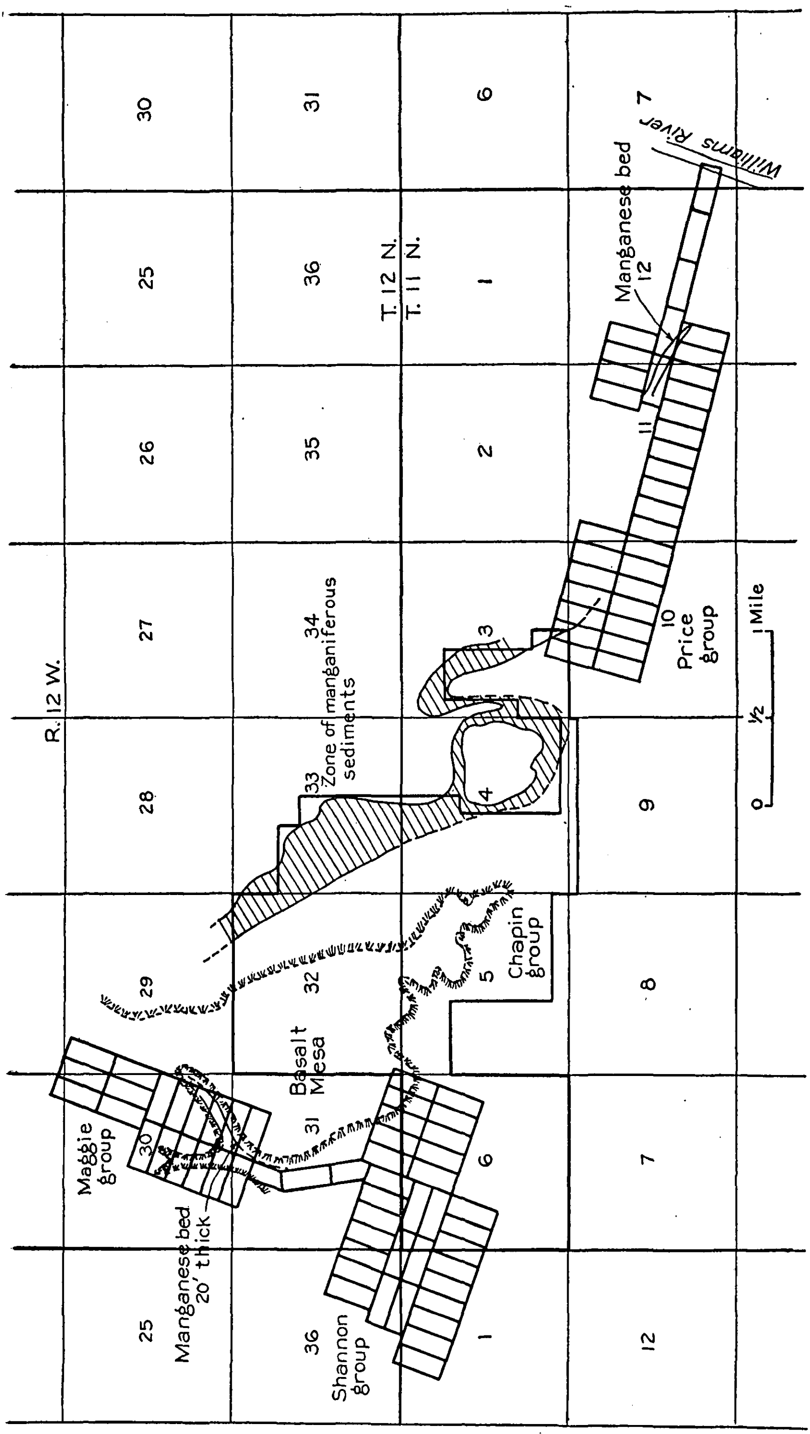

FIGURE 37.—Sketch map of claims filed on manganese deposits in Artillery Peak district, Mohave County, Ariz.

best exposure of a thick section careful sampling shows that the average manganese content of 56 feet is 7.6 percent. The zone thins rapidly outward from this section, but as 1 acre of such material would contain about 100,000 tons, there must be several million tons of manganese-bearing material in the area.

3. On the Chapin claims in sec. 3, T. 11 N., R. 12 W., two poorly defined beds of manganese-bearing latite tuff crop out, but the manganese content is low, and they have not been explored.

4. On the Price claims in sec. 12, T. 11 N., R. 12 W., on both sides of a narrow gulch, a zone of manganiferous tuff is exposed for a distance of about 2,000 feet. The zone trends east and dips south at a low angle. The thickness of the zone ranges from 20 feet at the east end to about 40 feet at the west end, but locally it is represented by two distinct beds separated by 12 to 30 feet of barren tuffaceous sand. Some samples show as much as 12 percent of manganese, but the average content is probably less than 5 percent.

Preliminary field mapping and explorations indicate that the beds exposed on the Maggie and northern Chapin claims occur in a single geologic formation, but that the principal beds on the two groups are not assuredly the same. It appears rather that the principal bed on the Maggie claims lies at a higher horizon than that on the Chapin claims. Whether either or both beds persist to the opposite sides of the basalt mesa is not yet clear; if they do persist in this manner and the grade is maintained, the total quantity of manganese under the area is obviously very much larger than the quantity stated above. Field evidence indicates that the deposits revealed on the lower Chapin and Price claims are found in the same geologic formations but in beds that were laid down in separate basins of sedimentation.

In addition to the bedded materials described above, the nearby area shows many irregular patches of brecciated rocks, in which there are numerous thin veinlets of manganese oxides. The containing bedrocks are cemented conglomerates and volcanic flows, which underlie the manganese-bearing tuffs as well as the sediments that contain these tuffs. The largest of these manganese-bearing bodies, 150 by 75 feet, is found on the Shannon claims. The manganese content of such bodies can only be inferred, but the total available manganese in most of them is small.

Even though these deposits occur in an isolated, unsettled region, remote from transportation and markets, they cannot be ignored as prospective sources of supply, because great progress has been made in recent years in concentrating such material into commercial products. The enormous tonnage that is readily minable is sure to stimulate experimental work on methods of treatment, and in the course of time it will probably be successful.

Topock.—In an area several miles in diameter, from 7 to 9 miles south of Powell, on the Atchison, Topeka & Santa Fe Railway, manganese deposits of the two types found near Artillery Peak were explored during the World War. Existing records indicate that they are smaller and lower in grade than those near Artillery Peak.

At a point on the Colorado River 42 miles north of Parker and 32 miles south of Powell veins of manganese oxides in basalt flows were explored during the World War. About 300 tons of good-grade ore was shipped, and several hundred tons more was mined. Although a small reserve exists, the region is remote from established transportation, and costs would be high.

YAVAPAI COUNTY

Mayer.—The Bunker claims, 12 miles southeast of Mayer, cover an area underlain by horizontal beds of sand and travertine that contain nodules of manganese oxides. During and since the World War about 750 tons of good ore has been shipped, but reserves are small.

●*Aguila.*—During the war and in 1923 about 1,300 tons of ore containing from 28 to 41 percent of manganese was mined from the Hatton claims, in Yavapai County 9 miles northwest of Aguila. The high-grade oxides are derived by weathering from black manganiferous calcite that forms a shoot in a persistent vein, most of which is barite and fluorite. The reserves are small.

Castle Creek.—Small bodies of manganese oxides have been explored in the Castle Creek district, but no shipments have been made.

YUMA COUNTY

●*Sheep Tanks.*—The veins of the Sheep Tanks mine, explored primarily for gold, contain considerable manganese, and small shipments are reported. The veins cut Tertiary volcanic rocks. The nearest railroad point, Vicksburg, lies 30 miles north. (See p. 33.) The probable reserve is small.

●*Planet.*—At the Iron King mine, 12 miles west of Midway, local masses of mixed manganese and iron minerals are found in a shear zone in pre-Cambrian rocks, about 100 feet wide and 1,000 feet long. A single shipment during the World War contained considerable silica. The reserve is small.

Bouse.—The Pyrolusite mine, 6 miles east of Bouse, explored a manganese-bearing shear zone in andesite during the war. About 150 tons of ore was shipped at that time, but the reserve is small.

Other areas.—Manganese-bearing deposits are known in other parts of Yuma County, notably the Ellsworth district, 34 miles southwest of Salome, and the Kaiserdoom claims, near the Santa Maria River, 33 miles west of Congress Junction, but no ore has been shipped from them, and they seem to be small.

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CALIFORNIA

IMPERIAL COUNTY

Chocolate Mountains.—This district lies about 32 miles northeast of Glamis, on the Southern Pacific Railroad. Two mines, the Tres Amigos and Tolbard, shipped about 3,500 tons of 42 percent manganese ore during the World War, and other deposits were explored. The ores were mined from veins 1 to 3 feet wide that follow fractures in Tertiary volcanic conglomerates. The explored veins become of low grade about 30 feet below the surface, but a small reserve is believed to exist.

INYO COUNTY

Several manganese deposits are reported from the eastern part of Inyo County, and even though none are known to have shipped ore, at least one, the April Fool, which lies 32 miles northwest of Zabriskie, offers promise of production. Like those in Imperial County, the oxides are found in veins that cut Tertiary conglomerate.

KERN COUNTY

Randsburg.—Only a few manganese deposits are recorded in Kern County. The three most important lie 6 to 8 miles west of Atolia; one has yielded a single small shipment, and another has been explored. The deposits are reported to be veins of rhodonite in slates of Calaveras (?) age. They do not offer promise of large production.

RIVERSIDE COUNTY

Ironwood.—This district includes several desert ranges in the eastern part of Riverside County. During the World War the Black Jack mine yielded about 2,500 tons, the nearby Dioxide mine about 1,100 tons, and several others smaller quantities. The Black Jack and some other deposits are simple veins in intrusive rocks; the Dioxide is a vein in limestone. There is a fair prospect for a small reserve.

The Doran deposit, 10 miles northwest of the Black Jack, is similar to it and has yielded a small output.

SAN BERNARDINO COUNTY

Manganese deposits have been explored in ten localities in San Bernardino County, but only three have yielded shipments—the Owl Holes mine (●), 35 miles west of Riggs, on the Tonopah & Tidewater Railroad; the Root mine (●), 5 miles northwest of Ludlow; and the Red Cross mine, 10 miles northwest of Drennan. The deposits at the Red Cross and Owl Holes mines lie along fracture zones in middle Tertiary conglomerates, and the Root deposit on a shear zone in Tertiary volcanic rocks. The total shipments aggregate about 2,000 tons, but the reserves are small.

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NEVADA

● CLARK COUNTY

Within an area of several hundred acres, 16 miles southeast of Las Vegas, one mine (the Three Kids) was extensively explored between 1917 and 1920 and shipped about 16,000 tons of manganese ore. Numerous excavations were made nearby. Recent examination has shown that the mine explored a part of a bed of high-grade oxides as much as 31 feet thick and numerous faulted segments. In a broad way, the bed trends northeast and dips 20°–25° NW. The richest ore is found in the southeastern part of the field, and both the thickness and grade decline westward and northward. On the assumption that the bed persists westward under the alluvium without diminution in thickness or manganese content it was estimated that the deposit contains about 500,000 tons of material whose manganese content is about 30 percent.

● LINCOLN COUNTY

The Prince Consolidated and Virginia Louise mines, in the southern part of the Pioche district, which primarily explored bodies of silver-bearing lead and zinc ores, have encountered large bodies of weathered siderite, of which about 350,000 tons has been shipped, largely for use as a flux. The average content of iron was 30 percent, and of manganese 11 percent. Reserves are estimated at several hundred thousand tons of similar material.

The Black Metals mine, in the Jackrabbit district, near Pioche, has recently shipped annually several hundred tons of high-grade manganese ore and as much as 12,000 tons of lower-grade material.

Recently the Comet mine has explored an ore body of mixed lead-zinc sulphides in a gangue of manganiferous siderite, from which it is planned to extract manganese (p. 61).

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SUMMARY

Of the numerous manganese deposits in the region, only two appear to deserve serious consideration; the others might produce ore in small quantity if a market, based upon the use of ore from these two, were created. The Artillery Peak deposit is large, but it is of very low grade and remote from railroads. The greatest hope for utilizing the ore from the Three Kids deposit lies in a ferromanganese plant near Las Vegas, and this seems worth considering.

COBALT AND NICKEL

NEVADA

CLARK COUNTY

Two districts in southern Nevada (Yellow Pine and Bunkerville) have been sources of small shipments of cobalt and nickel. In 1922 four mines in the Yellow Pine (Goodsprings) district shipped several lots of cobalt oxide ore, aggregating 20 tons, that contained from 6 to 29.18 percent of cobalt, and the presence of cobalt was noted in eight other mines. Without much doubt several hundred tons of material containing about 2 percent of cobalt could be readily produced from existing explorations, but conditions do not warrant the hope for a large reserve.

At two mines (the Key West and Great Eastern) in eastern Clark County explorations that were made primarily for copper encountered material that contained appreciable nickel and traces of cobalt, as well as platinum and copper. One lot of 45 tons contained 2.3 percent of copper, 1.79 percent of nickel, and 0.13 ounce of platinum metals to the ton. The metals are irregularly distributed through basic dikes that have been explored to a maximum depth of 312 feet, but the main workings have been inaccessible for several years. As two rather ambitious efforts to exploit the deposits in recent years have failed, it would appear that the ore bodies are too small or too low in grade to be workable at average prices for the metals (p. 54).

Specimens of the nickel arsenite, annabergite, have been found in the Yellow Pine mine, Goodsprings district.

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MOLYBDENUM

ARIZONA

The molybdate of lead, wulfenite, is found rather widely in Arizona, particularly in the metal-mining camps of Pima, Pinal (Mammoth mine), and Yuma (Castle Dome district and Old Yuma mine) Counties. None of the mines have maintained steady production over a period, but several lots of concentrate have been shipped. Most of the better sources lie more than 200 miles from Boulder Dam.

Molybdenite, the sulphide of molybdenum, is also found rather widely in Mohave County (Hualpai Mountains) and Pima County (Helvetia, Baboquivari, and Santa Rita Mountains). Small lots of selected ore have been shipped from three mines, and several deposits offer promise of small though steady production. The Hualpai Mountain area lies about 100 miles southeast of Boulder Dam.

CALIFORNIA

Molybdenite is recorded from several localities in southeastern California, as follows:

Inyo County: Union district, 7 miles east of Kearsarge, 20 miles west of Laws.

Riverside County: 4½ and 16 miles northeast of Corona.

San Bernardino County: Big Hunch mine, New York Mountains.

San Diego County: San Pasqual Valley, 40 miles east of San Diego.

Although small lots of selected material have been shipped from several of these properties for testing, not enough work has been done to hold out promise of an important source.

NEVADA

● CLARK COUNTY

Wulfenite has been observed at ten mines in the Yellow Pine district, but at only one, the Shenandoah, has an effort been made to treat and recover it. Recently the California Molybdenum Corporation has explored the ore body and built a tramway about 1 mile to loading bins, from which the crude ore is carried by trucks 3 miles to a mill at Sandy. It is locally reported that the fines, representing about 40 percent of the crude ore, yield about 1 ton of 20 percent molybdenum concentrate for each 20 tons of fines treated. Production was maintained through 1934; modest reserves of crude ore have been revealed.

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TUNGSTEN

ARIZONA

Of the three common tungsten minerals, wolframite, hübnerite, and scheelite, the first is most widely recorded in Arizona. It has been mined and shipped from the following localities and is recorded elsewhere:

Cochise County: Whetstone Mountains, near Tucson.

Gila County: Globe district.

Mohave County: Boriana mine, Hualpai Mountains.

Yavapai County: Tip Top and Eureka (Camp Wood) districts.

Hübnerite has been shipped from the Las Guigas Mountains, Santa Cruz County, and the Dragoon Mountains, Cochise County; scheelite has been shipped from the Cave Creek district, Maricopa County. Although only about half of these districts lie within 200 miles of Boulder Dam, these include the most consistently producing mines.

The Boriana mine (●), 18 miles east of Yucca, explores a vein zone 3 to 8 feet wide for a distance of about 2,950 feet in the main tunnel. The vein zone includes from one to four quartz veins that contain wolframite and scheelite, but although the tungstic oxide content of the quartz ranges from 2 to 3 percent, the yield of the ore as mined is only about 0.8 percent. The mine is well equipped and records regular shipment since 1931, as well as earlier.

CALIFORNIA

In southeastern California tungsten minerals, largely scheelite, are widely distributed. The lodes and placers of the Atolia district, San Bernardino County, have been the principal source of tungsten in the United States for 20 years. Several districts near Bishop, Inyo County, have been important sources from time to time, and the Kernville, Bald Mountain, and Weldon districts, in Kern County, and the Clark Mountain, New York Mountains, and Signal districts, in San Bernardino County, made shipments principally during the World War but only sporadically since then.

● *Atolia.*—Mining of scheelite ores in the Atolia district is largely confined to one major and several minor vein systems and two deposits of alluvium in an area of 2 square miles near Atolia. The Stringer district, several mines in which have yielded a small production, lies 2 miles west of the Atolia district. The main shaft of the Atolia Mining Co., which owns most of the productive area, attains a vertical depth of 750 feet (1,400 level). The vein averages about 3 feet in width and recently the crude ore has yielded about 15 pounds of 65 percent tungstic oxide concentrate to the ton. The alluvium from a pit about 1,000 feet in diameter, 1,500 feet southeast of Atolia, has been removed to a depth of 15 to 30 feet for concentration. Recently a second area, 2,500 feet southwest of Atolia, has been explored. The total yield of tungstic oxide from all concentrate to the end of 1930 is about 600,000 units (20 pounds each), or about 6,000 tons. As long as prices exceed $10 per unit of tungstic oxide, a fairly steady production of ore may be expected from the lode mines for some years.

Sporadic bodies of carbonate rocks that show alteration zones near intrusive igneous rocks have been found to contain small percentages of scheelite in several localities in Inyo, Kern, Riverside, and San Bernardino Counties. The most ambitious efforts to mine and recover such ores have been made in the 20-mile belt that extends from Big Pine to Round Valley, Inyo County, but this belt lies outside the area under review.

In eastern San Bernardino County, near Clark Mountain and in the Signal district, north of Goffs, narrow quartz veins were mined during the World War for their content of wolframite and hübnerite, but they have not been worked since that time.

NEVADA

Although small quantities of tungsten minerals are known to occur here and there in southeastern Nevada (for example, in the Comet mine, Pioche district), there is no record of attempts to mine them. The minerals occur at many places in central and northern Nevada, and several important mines have been developed in recent years, notably those near Mill City, Pershing County. Although these lie about 370 miles northwest of Boulder Dam, any attempts to smelt tungsten ores near the dam would draw concentrate from the district.

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VANADIUM

ARIZONA

Vanadates of lead, copper, and zinc are recorded in many localities in Arizona—in Cochise, Coconino, Gila, Maricopa, Mohave, Pinal, Pima, Yavapai, and Yuma Counties. Only a few of these localities lie within 200 miles of Boulder Dam—four in Mohave County, 1 in Coconino County, 2 in Maricopa County, and 7 in Yavapai County. So far as the record is available, only two deposits in Arizona have been vigorously exploited as sources of vanadates—that in the Dripping Spring Mountains, Pinal County, 10 miles northwest of Christmas, and that near Radium, Gila County.

CALIFORNIA

Vanadates are found in the Signal district (●), San Bernardino County, Calif., and about 1916 efforts were made to recover them at two mills. There is no record of shipments.

NEVADA

● CLARK COUNTY

Although vanadates of lead, zinc, and copper occur widely in the Yellow Pine (Goodsprings) district and several other metalliferous districts in Nevada, efforts to recover them have been made at only a few mines, notably the Fredrickson, Hoodoo, and Spelter. Only a few tons of concentrate has been shipped, and even though the minerals are widespread, it seems doubtful whether the quantity is large enough to sustain an active industry.

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SUMMARY

The two operations on tungsten deposits, Atolia and Boriana, are sufficiently well established to justify consideration of a ferrotungsten plant near Las Vegas. If such a plant were built, other tungsten mines in the region would undoubtedly contribute concentrate from time to time. The deposits of the other ferroalloy metals could not alone justify reduction plants, but if such plants were built for ferromanganese or ferrotungsten, they might offer an outlet for any concentrate from the other deposits.

NONMETALLIFEROUS RESOURCES

HEAVY CHEMICAL MINERALS

SALINES[63]

ARIZONA

YAVAPAI COUNTY

● *Camp Verde.*—Thenardite (anhydrous sodium sulphate) and salt occur in Pliocene or Pleistocene lake beds (Verde formation) south of Camp Verde, Ariz. The main deposit consists of a 4-foot bed of thenardite, salt, and mud that crops out in a group of low hills 2 miles southwest of Camp Verde. Smaller remnants of the once extensive deposit have been found 4 miles to the south. One property has been the source of production, and the output has been largely anhydrous sodium sulphate, which has been obtained by both

[63] Examined by B. N. Moore unless stated otherwise.

stripping and tunneling in an area of about 100 acres. The ore is treated by washing in a mill on the property to remove the mud and more easily soluble salt, and the sulphate, after drying in a kiln, is sacked and trucked 20 miles to the railroad at Clemenceau. Since 1930 the production has been about 75,000 tons. No information is available about the extent and size of the various beds in this district, but the reserves are probably large.

CALIFORNIA

IMPERIAL COUNTY

Bertram.—Thenardite is found in tilted Tertiary strata about 2½ miles northeast of Bertram station, in the Salton Sink. About 2,500 tons of anhydrous sodium sulphate was shipped in 1923. The deposit was inaccessible in 1934.

INYO COUNTY

● *Owens Lake.*—On the basis of analyses of the brine and the volume of Owens Lake as shown by subsurface contour maps, H. S. Gale estimated the saline content of the lake at 160,000,000 tons. The composition of the brine in 1912 was as follows:

Composition of brine from Owens Lake, Inyo County, Calif.

[W. B. Hicks, analyst]

	Percent
Chloride (Cl)	25.56
Sulphate (SO_4)	9.96
Carbonate (CO_3)	22.18
Borate (B_4O_7)	1.92
Sodium (Na)	38.07
Potassium (K)	2.10
Silica (SiO_2)	.21
	100.00

Total anhydrous salts, 10.95 percent of brine.
Specific gravity at 21°/20° C., 1.0977.

On the basis of this analysis the amounts of solid matter dissolved in the brine may be recomputed approximately as follows:

Saline content of Owens Lake recalculated to hypothetical salts

	Tons
Potassium chloride (KCl)	6,400,000
Borax, anhydrous ($Na_2B_4O_7$)	4,000,000
Salt (NaCl)	62,650,000
Sodium sulphate (Na_2SO_4)	23,600,000
Sodium carbonate (Na_2CO_3)	63,000,000
Silica (SiO_2)	350,000
Total	160,000,000

Since the diversion of the waters of the Owens River to Los Angeles, drying up of the lake has greatly concentrated the brine, and in cold weather the lake is covered with a nearly solid crust of trona (a double salt of sodium carbonate and bircarbonate). As the quantity of salts removed by the operators in recent years is relatively small, that which remains is essentially the same as the estimate above.

Plants have been erected on both the east and west sides of the lake to recover the solid trona and soda ash from the brines. These plants are served by the narrow-gage Owenyo branch of the Southern Pacific Railroad. One plant south of Keeler, on the east side of the lake, was operating at the time of visit. The process provided for saturating brines from the lake with carbon dioxide gas obtained by burning limestone quarried in the Inyo Mountains, to the north, removing the precipitated sodium bicarbonate, and roasting the bicarbonate to the carbonate. The capacity was about 100 tons of soda ash (anhydrous sodium carbonate) a day.

KERN COUNTY

● *Saltdale.*—Brines from Kane Dry Lake, south of Saltdale, are worked by solar evaporation, and a small annual production of salt is maintained. One operator is located on the Southern Pacific Railroad.

SAN BERNARDINO COUNTY

● *Avawatz Mountains.*—Thick beds of salt are found in the tilted Tertiary strata along the northeast face of the Avawatz Mountains. The enclosing beds have been considerably squeezed, and the salt is of irregular extent. The district has been thoroughly prospected, but no production has been made. The nearest shipping point is 30 miles east, at Riggs, on the Tonopah & Tidewater Railroad.

● *Bristol Dry Lake.*—The clays and sands of Bristol Dry Lake, southeast of Amboy, are underlain at a depth of about 5 feet by a layer of coarsely crystalline salt that covers more than 5,000 acres and is 5 feet thick in the main workings. The salt forms a solid but porous mass of large cubical crystals with the interstices filled with brine and small amounts of green mud. It is worked by strip mining, and two plants have been built, one of which was in operation at the time of visit. The salt is hauled to the plant from the pits by gasoline locomotives, crushed, and cleansed of impurities by washing with brine. The plants are on spurs from the Atchison, Topeka & Santa Fe Railway. The brine associated with the salt is notable for its large concentration of calcium chloride. From 1919 to 1929 more than 40,000 tons of calcium chloride was produced. The reserves of both salt and calcium chloride are very large.

Cadiz Dry Lake.—The muds of Cadiz Dry Lake are reported to be underlain by thick deposits of salt and gypsum. Like the brine of Bristol Dry Lake, the Cadiz brine is notable for a large concentration of calcium chloride:

Composition of brine from Cadiz Dry Lake, San Bernardino County, Calif.

[Smith, Emery & Co., Los Angeles, analysts. Composition recalculated to hypothetical combinations]

	Percent
Potassium chloride (KCl)	2.69
Salt (NaCl)	78.04
Calcium chloride ($CaCl_2$)	16.53
Magnesium chloride ($MgCl_2$)	2.20
Gypsum ($CaSO_4$)	.54
Total	100.00

Fused salts, 7.36 percent.

No production or development of this deposit is known.

● *Dale Dry Lake.*—The brines of Dale Dry Lake, which lies 40 miles by a poor road from Amboy, contain large amounts of sodium sulphate and salt. Experiments are being conducted at the lake to devise a process for separating sodium sulphate from the brine by solar evaporation. No production has been recorded and there are no data as to the size of reserves.

● *Danby Dry Lake.*—The surface muds of Danby Dry Lake are underlain by thick beds of salt and gypsum. Small amounts of salt have been mined in the past for use in chloridizing silver ores in nearby mines. The reserves are probably very large.

● *Searles Lake.*—The playa in which Searles Lake lies includes about 60 square miles. An area of about 12 square miles near the center is composed of crystalline salts and brine with a mean thickness of about 70 feet, known as the "crystal body." Outside this body the salts and brines grade into the playa muds. The salts consist largely of halite (NaCl), trona ($Na_2CO_3.NaHCO_3.2H_2O$), hanksite ($9Na_2SO_4.2Na_2CO_3KCl$), borax ($Na_2B_4O_7.10H_2O$), and glaserite ($3K_2SO_4.Na_2SO_4$), with some rarer salts such as sulphohalite ($3Na_2SO_4.NaCl.NaF$). Not enough detailed work has been done to determine the amounts of brine or salts with any degree of accuracy, and the following statements are made merely to give an idea of the magnitude of the amounts involved.

An estimate of the total amount of salts in the "crystal body" alone, based on an average density of 2.0, a mean thickness of 70 feet, an extent of 12 square miles, and a porosity of 25 percent, is about 1,090,000,000 short tons. The porosity of the salt body has been variously estimated as from 25 to 50 or even 60 percent. On the basis of a 25 percent porosity the brine is estimated to amount to nearly 250,000,000 tons with a density of about 1.29. The amounts of brine and salts in the playa muds cannot be estimated, but it is significant that wells noted by Thompson about 1 to 2 miles north of the playa show only 0.1 to 0.2 percent of solids in their waters, possibly indicating a gradual decrease in concentration from the salt body outward.

Analyses quoted by Gale indicate that the composition of the salts, in terms of common industrial chemicals, is about half salt ($NaCl$) with the remainder largely sodium sulphate (Na_2SO_4) and sodium carbonate (Na_2CO_3) with small amounts of borax ($Na_2B_4O_7$) and potassium chloride (KCl). In the following table an analysis given by Teeple is quoted along with rough estimates of the amounts of the various salts based on a total amount of 250,000,000 short tons of brine:

Composition of brine pumped from Searles Lake, San Bernardino County, Calif., computed as hypothetical salts

[American Potash & Chemical Corporation, analyst]

	Percent by weight	Approximate equivalent based on 25 percent porosity of salt body (short tons)
Sodium chloride	16.50	
Sodium sulphate	6.82	17,000,000
Potassium chloride	4.82	12,000,000
Sodium carbonate	4.80	12,000,000
Borax	1.51	3,000,000
Sodium phosphate	.155	
Sodium bromide	.109	270,000
Lithium chloride	.021	
Sodium sulphide	.020	
Arsenious oxide	.019	
Lime	.0022	
Iron and aluminum oxides	.0020	
Ammonia	.0018	
Sodium iodide	.0014	
Antimony oxide	.0006	
Total anhydrous solids	34.782	

Specific gravity at 70° F., 1.30.

At present two plants are producing salts from the brines. The American Potash & Chemical Corporation, successor to the old Trona Co., produces potash salts, borax, boric acid, sodium sulphate, and sodium carbonate and may in the future produce bromides. The Westend Chemical Co. produces borax and sodium carbonate. The plants are connected with the Southern Pacific Railroad by the Trona Railroad.

● *Wright.*—Efflorescences of salts containing epsomite (magnesium sulphate) occur on outcrops of Tertiary clay beds in Wingate Pass. A considerable investment was made in a plant at the south end of Searles Lake and in 30 miles of monorail to the deposit, but the project has been abandoned.

NEVADA

CLARK COUNTY

Virgin Valley.—Beds of rock salt have been known in Virgin Valley for many years, and some claims were recorded as early as 1880, when the salt was used to treat silver ore mined in the Calico district, near Barstow. According to Longwell, the salt forms definite beds in the Muddy Creek formation, of Tertiary (probably Pliocene) age. At one exposure a bed of salt 85 feet thick is shown. The upper surface of the bed is irregular, and the average thickness and areal extent of the bed are not known. Existing exposures and explorations indicate the possibility of the existence of a large quantity of salt in the region. All the exposures of salt will be submerged when water rises to the crest of Boulder Dam.

MINERAL COUNTY

Rhodes Marsh.—In early days large amounts of ulexite, or cottonball, a borax mineral, were collected from the surface of Rhodes Marsh. These deposits were exhausted, but large amounts of sodium sulphate and salt remain. The marsh is roughly 3 miles wide from northeast to southwest and about 2 miles from southeast to northwest. The surface is irregular and consists largely of salt and mirabilite (hydrous sodium sulphate), which dissolve in the brine in summer but crystallize to a solid mass in cold weather. Pits dug on the east side of the marsh show that the mirabilite is merely surficial and that the main body of salts consists largely of thenardite (anhydrous sodium sulphate) and salt. The Rhodes Alkali & Chemical Co. mines the salt and thenardite by stripping. The salt and dirt are removed at its plant by washing them away from the less readily soluble thenardite. No prospecting has yet been done to determine the size of the salt-thenardite body, but there are probably very large reserves.

SUMMARY

Large amounts of salines such as sodium chloride, sodium carbonate, sodium sulphate, potassium chloride, borax, and calcium chloride are found in accessible and workable deposits in this region. However, the work of private individuals and of the United States Geological Survey has shown that saline deposits do not underlie all the basins in the region. It should also be added that nitrate deposits do not exist in commercial size. The following remarks by Gale are particularly pertinent:

> The dominant idea in the exploration of the desert basins for saline and potash concentrations depended on the assumption of former saline lakes whose waters by evaporation have left their salts as massive saline residues.

* * * At first it was very generally assumed that such lakes had existed in almost all the enclosed drainage basins, chiefly because these areas were alike in not having any present outlet, and the rise of their waters was supposed to have been due to a prevailing more humid climate. On further consideration, however, it is now believed more likely that these ancient lakes were not so widely distributed in the desert region as first assumed, and it is even probable that large or persistent water bodies of this type were confined to relatively few areas. Therefore saline concentration in the desert basins may have been going on for long periods under intermittent lake or playa conditions, but the accumulation and deposition of salts in thick crystalline masses as a result of the desiccation of major saline lakes has perhaps been of comparatively rare occurrence.

One of the disappointments of early investigators was the absence of commercial concentration of potash salts in the desert basin deposits. Concerning this, Gale says:

Perhaps the most important factor influencing the disposition of the soluble potash contained in natural drainage waters is the power which clays have of absorbing potash when brought into contact with its solutions. It appears that herein lies the actual explanation of the apparent disappearance of much of the potassium salts from solutions or from the saline deposits collected in the desert basins. * * *

As a summary it is probably safe to say that commercially valuable concentrations of potash are not to be looked for in the desert-basin deposits generally.

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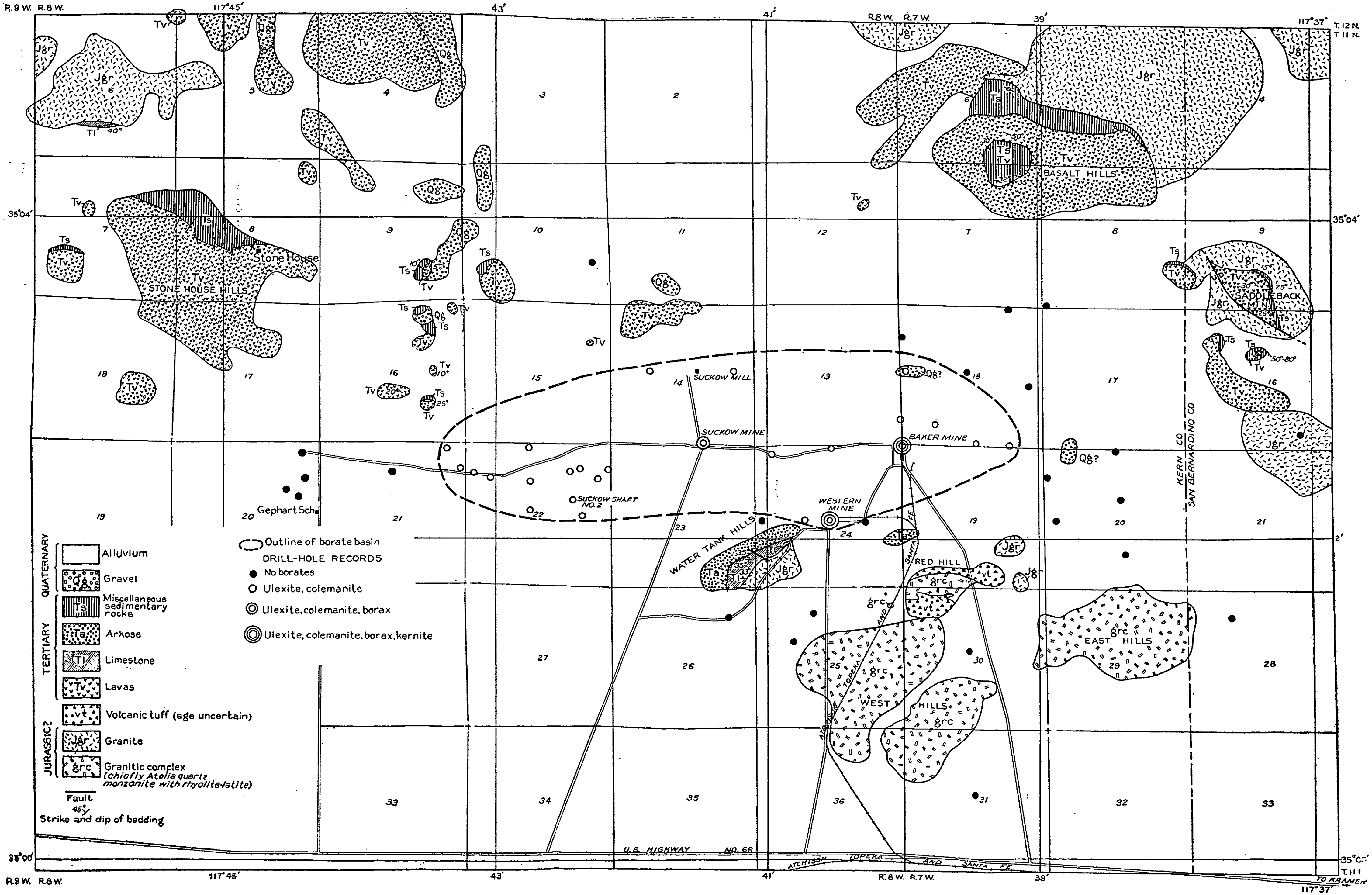
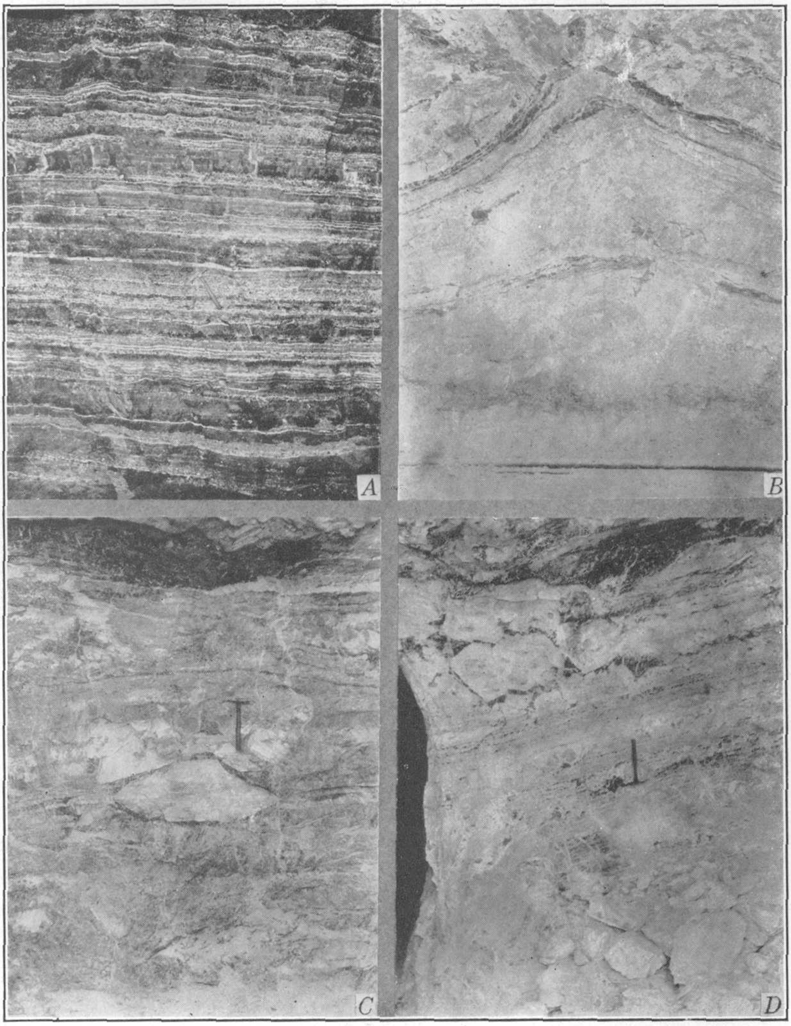
BORATES

The Boulder Dam region contains the world's principal source of borate minerals. Large deposits occur in both Nevada and California, though those in California supply the entire output at the

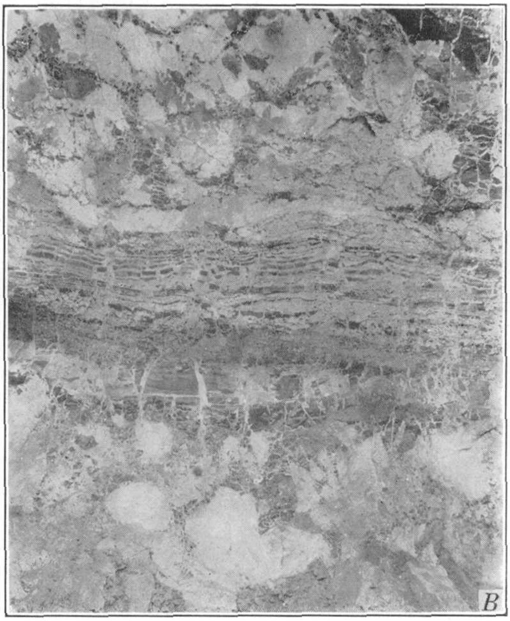


GEOLOGIC MAP OF THE KRAMER BORATE AREA, CALIFORNIA.



RELATIONS OF SHALE LAYERS TO SODIUM BORATES IN THE KRAMER FIELD.

A, Typical view of a face (about 9 feet high) of a drift in the Suckow mine. Looking northeast; therefore does not show the 8° dip of the beds. Note the continuity and parallelism of the beds. White, shale beds, covered with white efflorescence of tincalconite. Dark, borax, the dark color being due to enclosed impurities (clay). Note also the absence of major folds and of areas of disturbance with disruption of the beds and the scattering of broken fragments of shale throughout the borax.
B, An anticlinal fold of the beds in the Baker mine, level 2. Face about 8 feet high.
C, Large kernite crystal, 1 foot high and 3 feet wide, with shale layers pushed aside and now surrounding it. Baker mine, level 3. Face about 8 feet high.
D, Group of kernite crystals (upper part) in close proximity to one another, with shale surrounding each kernite crystal, at least in part. Western mine. Face about 9 feet high. At the bottom is a loose pile of kernite.



RELATIONS OF SHALE LAYERS TO SODIUM BORATES IN THE KRAMER FIELD.

A, Large kernite crystals with irregular, disrupted masses of shale. Note the more uniform character of the shale layers in the borax above the kernite. Baker mine, level 2. Face about 4 feet high.

B, Kernite, with irregular shale masses, above and below a borax layer in which the continuity and parallelism of the shale beds have largely been preserved. In the center of the borax layer is a small area in which the disconnected shale fragments have been variously oriented. Western mine. Face about 8 feet high.

present time. Reserves are large and will supply the current needs of borate products for a great many years.

The power requirements of the borate-mining industry are small and are already supplied by existing plants. However, the presence of abundant supplies of borate minerals near the dam may promote the establishment of industries that would use borates and require cheap power.

The principal minerals from which boron products have been produced are native borax or tincal (hydrous sodium borate), kernite (sodium borate with less water than borax), ulexite (hydrous sodium and calcium borate), and colemanite (hydrous calcium borate). Native borax, obtained largely from borax marshes and dry lakes in Nevada and California, was the first source of borates to be exploited. The discovery of colemanite in beds within Tertiary rocks in this same region caused a complete shift of the borate-mining industry. Abrupt changes in the sources took place as new and more cheaply minable deposits were discovered. The Calico deposit, in San Bernardino County, Calif.; the Death Valley deposits; and the Muddy Mountains deposits, in Clark County, Nev., had periods of intensive development. The discovery (1925) and exploration (1926) of the very large deposits of borax and kernite at Kramer, in Kern County, Calif., completely changed the source picture, and almost all other underground borate mines were closed. Other fields have not necessarily been exhausted, but the low cost of mining and treatment of the kernite and borax at Kramer and the recovery of borates from Searles Lake have made it unprofitable to operate the colemanite deposits.

CALIFORNIA

By Waldemar T. Schaller

KERN COUNTY

The Kramer borate area is about halfway between Barstow and Mojave and 7 miles northwest of Kramer. The oval area in which borate minerals have been found is 4 miles long in an east-west direction and 1 mile wide. It lies in secs. 13, 14, 15, 16, 21, 22, 23, and 24, T. 11 N., R. 8 W., and secs. 18 and 19, T. 11 N., R. 7 W. Two of the mines are served by a branch of the Atchison, Topeka & Santa Fe Railway and are about 3 miles north of the paved highway.

The principal mine and the only one operating at present is the Baker mine of the Pacific Coast Borax Co. Two other mines, the Suckow mine of the Suckow Borax Co., in which the Pacific Coast Borax Co. has a half interest as co-tenant, and the Western mine of the former Western Borax Co., wholly owned by the Pacific Coast

Borax Co., are not now active. Additional shafts and drill holes have outlined the probable extent of the borate area, as shown in plate 1. The borate area is nearly level, and there are no unusual difficulties involved in road construction or installation of plants.

General geology.—The beds containing borax, kernite, ulexite, and colemanite occur within Tertiary sediments and associated lavas, which lie upon a floor of older metamorphic and igneous rocks and younger granite and quartz monzonite (of probable Jurassic age). Most of the area is covered by alluvium, as shown on plate 1. The Tertiary sediments lie in a synclinal basin, and the older rocks crop out on almost all sides.

A generalized stratigraphic section of the sediments and lavas that lie upon the granitic floor is given below.

General stratigraphic sequence of rocks in the Kramer area

	Rocks			Depth of top (feet)	Thickness (feet)
Quaternary	Alluvium			0–900	[1] 0–900
Tertiary	Sediments and lavas	Upper sediments	Borate-free clays	54–905	15–315
			Borate clays and shales	110–1, 100	85–210
			Borate-free clays and shales	357–1, 195	55+
		Lavas		[2] 124–616	
		Lower sediments (tuffs, limestones, etc.)		(3)	1, 000+
(?)	Banded volcanic tuff on Red Hill. Porphyritic rhyolite-latite on East and West Hills.				
Pre-Tertiary (?) (Jurassic ?).	Basement complex, granitic.				

[1] Taken from available drill records, which may not have distinguished between the Quaternary alluvium and the underlying Tertiary arkose.
[2] Refers only to the lavas buried under the upper sediments.
[3] So far as known, none of the lower sediments were definitely encountered in any of the mines or drill holes.

The lavas are chiefly basalts, but associated with them are agglomerates and breccias and some rhyolitic lavas. They are exposed at many places around the borate basin and are revealed by drill cores as underlying the borate beds but are not known to overlie them. The Tertiary sediments are dominantly soft and crop out only along ridges made by resistant lava and cherty limestone, but they probably underlie a large part of the area covered by alluvium. This relation explains why the borates were discovered only by drilling. No outcrop of the borate beds is known. Broadly, the rocks lying above the granitic basement consist of (1) a series of indurated beds overlain and in part interbedded with (2) lavas, which in turn are overlain by (3) clay beds containing the borate lenses. These rocks are similar to and are probably part of the Rosamond series of

Hershey,[64] which in places outside the Kramer area contains vertebrate fossils and is regarded as of late Miocene and probably early Pliocene age. Abrupt variations occur in composition and thickness of the beds along the strike as well as between different beds.

The lower group of sediments is more indurated than the borate-bearing clays and shales. It consists largely of greenish clayey material mixed with arkosic and tuffaceous material; both glassy and lithic volcanic tuffs, in part compacted but mostly still friable; cherty, dolomitic, and brecciated limestone; massive and finely laminated chert; both consolidated and unconsolidated arkose; reddish-brown and green shale; arkosic sandstone and fanglomerate. Interbedded lavas and agglomerates are found throughout the formation. The total thickness of these sediments in the Water Tank Hills is about 1,000 feet. In other exposures the thickness is much less. The series of hard limestone beds in the Water Tank Hills aggregates several hundred feet in thickness.

The later sediments, which contain the borate minerals, consist chiefly of clay and shale with beds of arkosic sandstone and tuff. These rocks were observed only underground in the mines and in the Suckow No. 2 shaft,[65] in sec. 22, T. 11 N., R. 8 W. They are divided into three groups, though the lower group of clays is known only from drill holes, which have penetrated it to depths ranging from 7 to 55 feet below the base of the borate-bearing beds. The middle part of the upper group of sediments contains the borate minerals and ranges in thickness from 85 to 210 feet, according to drill records. The depth of the top of these beds below the surface ranges mostly between 325 and 900 feet. Two beds of tuff, "hard beds", each 1½ feet thick, occur in the Western mine. The upper part of the upper group of sediments in the Suckow No. 2 shaft consists of pale-greenish, somewhat sandy clay shale with arkosic sandstone and volcanic ash. The upper part is known elsewhere from drill records only. The top lies from 54 to 905 feet below the surface, and the thickness ranges from 15 to 315 feet.

Surface alluvium covers most of the area and is recorded in wells as being as much as 900 feet thick. Quaternary gravel is mapped separately in places but has been included in the alluvium elsewhere. In nearly all the flat areas the alluvium mostly ranges in thickness from 300 to about 800 feet, according to drill records.

The borate-bearing beds are in a synclinal basin whose axis trends east. As exposed in the three mines the beds are nearly horizontal,

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[64] Hershey, O. H., Some Tertiary formations of southern California: Am. Geologist, vol. 29, pp. 365–372, 1902. Hulin, C. D., Geology and ore deposits of the Randsburg quadrangle, Calif.: California State Min. Bur. Bull. 95, pp. 42–48, 1925.

[65] Noble, L. F., Borate deposits in the Kramer district, Kern County, Calif.: U. S. Geol. Survey Bull. 785, pp. 48–50, 1926.

but sediments and lavas exposed around the margins of the basin dip roughly toward the center at angles commonly around 35°, though there are variations in dip from 20° to 90° (pl. 1). Faults occur in the outcrops around the margin of the basin, and a fault half a mile long was traced on the west and south sides of Saddleback Mountain. A prominent group of faults also occurs on the north side of the Stonehouse Hills.

In the Suckow mine the clay beds that contain the borate layers dip uniformly 8° NE. In drifts in the Baker and Western mines the clay beds are nearly flat for great distances, but in places there are evidences of minor warping, slumping, and faulting, though the diverse dips are usually not more than 10°. Displacements on minor faults are mostly only a few inches, though displacements of several feet were noted at a few places. In the Baker and Western mines also there are crushed areas or mixtures of borate minerals with heterogeneously arranged fragments of shale. Viewed broadly, deformation of the bed is not a serious factor in the extraction of borates from the mines so far developed.

The deposits.—Borate minerals that occur in sufficient quantity to be mined are borax, kernite, colemanite, and ulexite, which, so far as is known, are limited to the area outlined on plate 1. Tincalconite and probertite (kramerite) are also present, but sassolite, larderellite, and ammonioborite are absent. The composition of these minerals is given below:

Kernite	$Na_2O.2B_2O_3.4H_2O$.
Tincalconite	$Na_2O.2B_2O_3.5H_2O$.
Borax	$Na_2O.2B_2O_3.10H_2O$.
Colemanite	$2CaO.3B_2O_3.5H_2O$.
Probertite	$Na_2O.2CaO.5B_2O_3.10H_2O$.
Ulexite	$Na_2O.2CaO.5B_2O_3.16H_2O$.
Sassolite	$B_2O_3.3H_2O$.
Larderellite	$(NH_4)_2O.5B_2O_3.5H_2O$.
Ammonioborite	$(NH_4)_2O.5B_2O_3.5H_2O$.

Borax and a little tincalconite but no kernite or probertite were obtained from the Suckow mine, whereas borax and kernite with a little tincalconite and probertite were obtained from the Baker and Western mines.

The borate minerals occur as nearly horizontal tabular bodies or beds parallel to the bedding of the enclosing clays and shales. These bodies have considerable areal extent and in places are rather thick. According to Tucker,[66] the ore body in the Baker mine as explored in 1929 had a thickness ranging from 85 to 114 feet and was said to be proved for 1,500 feet north and south and about 1,200 feet

[66] Tucker, W. B., Los Angeles field division, Kern County: Mining in California, vol. 25, p. 79, California State Min. Bur., 1929.

east and west. The tops of these tabular bodies are from 350 to 400 feet below the surface in the Baker and Suckow mines and about 800 feet in the Western mine. The borax and kernite in the Baker and Western mines occur either as a heterogeneous mixture, as roughly alternating parallel layers, or as large masses of pure borax or pure kernite. Layers of borax having an average thickness of 10 feet lie both above and below the kernite. At the margins of the bodies of borax and kernite the hanging and foot walls, which contain ulexite, come together, and granular lumps of borax a foot in diameter are scattered through the clay for a short distance from the edge of the deposit. In those parts of the Baker and Western mines where kernite is abundant the bedding of the shale is as a rule greatly disturbed. (See pls. 2 and 3.) Where borax and no kernite is present as in the northern part of the Baker mine the bedding is moderately continuous and regular; in the Suckow mine where only borax is present the bedding is very regular. In places in all three mines there are vertical veins of borax, few of them more than several inches wide.

No definite information is available as to the relative quantities of borax and kernite in the deposit as a whole, but the borax is very abundant and probably exceeds the kernite. The statement previously made by the writer [67] that he "would estimate that not less than 75 percent of the deposit is formed of this striking mineral [kernite]" should be changed to read "of borates of soda"—that is, kernite and borax—for drifts open in 1927 were mostly within kernite. On the assumption that the ore body as mined is one quarter clay and three quarters borate of soda and that borax and kernite are present in about equal quantities, the material should yield 90 percent of borax by weight after refining, without allowance for refining losses.

The origin of so large a deposit of borate minerals having a commercial advantage over colemanite, which is the principal borate mineral in most large borate deposits, is of considerable interest, particularly as an illustration of a natural "refining" of a mineral product. As Foshag [68] has stated, the original source of the boron in the borate deposits of the Southwest "is most probably to be found in the hot springs and solfataras connected with the tremendous volcanic activity that characterized the Tertiary period, when these deposits first accumulated."

Ulexite, the lime-soda borate, appears to be one of the first minerals, if not the first, in which the boron is fixed. It is known to

[67] Schaller, W. T., Borate minerals from the Kramer district, Mohave Desert, Calif.: U. S. Geol. Survey Prof. Paper 158, p. 146, 1930.

[68] Foshag, W. F., The origin of the colemanite deposits of California: Econ. Geology, vol. 16, pp. 210–211, 1921.

have formed in clay in large quantities free from other saline minerals and to change by leaching to colemanite and borax according to the following reaction:

$$\underset{\text{Ulexite}}{Na_2O.2CaO.5B_2O_3.16H_2O} \rightarrow \underset{\text{Borax}}{Na_2O.2B_2O_3.10H_2O} + \underset{\text{Colemanite}}{2CaO.3B_2O_3.5H_2O}$$

The alteration of ulexite to colemanite with release of sodium borate has occurred in the Kramer area, as stated by Noble [69] and Gale.[70] From a conservative estimate of the known size of the borate basin, an elliptical body of ulexite-bearing clay shale 50 feet thick would have been sufficient to yield a quantity of borax comparable with the known extent of the borax and kernite deposits.

The thin-bedded shales in the Kramer area are undoubtedly of lacustrine origin. Repeated leaching of ulexite and concentration of borax along with deposition of mud and volcanic ash might produce beds of borax in shale such as are seen in the Suckow mine. The writer has previously suggested [71] that concentration of borax in the eastern part of the basin might have been brought about by prevailing westerly winds, as borax crystals readily dehydrate to tincalconite, a white powder, which could be transported by wind and deposited in water as borax. The leaching of ulexite originally would account for the notable absence of other desiccation products, such as the carbonate and chloride of soda (trona and halite), which at many other localities occur in sediments of this type.

The dehydration of borax to form kernite is a process of especial interest in an understanding of the deposit. Kernite contains the least water of all the hydrous sodium borates and has the highest temperature range of stability. The volume is also diminished in this process, provided the excess water is free to escape, for borax has a specific gravity of 1.72, whereas that of kernite is about 1.91. It seems reasonable, therefore, to assume that kernite was derived from borax by the application of heat and the expulsion of part of its contained water, with possibly a factor of increased pressure. Perhaps the additional localized heat could be supplied by an intrusive igneous body, but the fact that the kernite occurs in those areas in which deformation has been most intense strongly suggests that it may have been formed by the pressure and increased heat brought about by the deformation. Kernite is restricted to shale beds that have been considerably disturbed. Probertite, which is similar to ulexite except that it has less water and a higher temperature range of stability, occurs with the kernite but not in borax

[69] Noble, L. F., Borate deposits in the Kramer district, Kern County, Calif.: U. S. Geol. Survey Bull. 785, pp. 47, 50, 51, 1926.

[70] Gale, H. S., Borate deposits near Kramer, Calif.: Am. Inst. Min. Met. Eng. Trans., vol. 73, pp. 449, 450, 452, 1926.

[71] Schaller, W. T., op. cit., p. 167.

beds, as at the Suckow mine. This association further suggests that the formation of kernite has involved locally increased temperatures in beds of borax. The fact that enclosing beds of shale near the borax beds are not deformed, as they would be if the borax had formed from kernite, with consequent increased volume, indicated strongly that kernite was formed from borax, rather than borax from kernite.

Production and reserves.—Detailed figures on production of crude borates from the Kramer area are not available, but the total production prior to 1935 is estimated at close to 1,000,000 short tons. The average monthly shipment from the Baker mine prior to 1933 was about 6,500 short tons, but this figure has since been doubled. Beginning with 1929, the total quantity of boron minerals sold or used by producers in the United States has been about 180,000 short tons annually, of which the Kramer deposits are estimated to supply approximately two-thirds.[72]

Permission to publish figures on reserves cannot be obtained, but it may be stated with assurance that the Kramer area is capable of supplying enormous quantities of borates for many years.

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Gale, H. S., Naming the new borax mineral: Eng. and Min. Jour., vol. 125, p. 702, 1928.

Tucker, W. B., Los Angeles field division, Kern County: Mining in California, vol. 25, pp. 77–81, 1929.

Eakle, A. S., Probertite, a new borate: Am. Mineralogist, vol. 14, pp. 427–430, 1929.

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[72] Santmyers, R. M., Boron and its compounds: U. S. Bur. Mines Inf. Circ. 6499, p. 14, 1931.

NEVADA

CLARK COUNTY

By Eugene Callaghan and W. W. Rubey

Deposits of colemanite were discovered in the Muddy Mountains, north of Boulder Dam, in the later part of 1920. White Basin, the first area to be discovered, lies 24.5 miles in a direct line north-northeast of the dam; and the West End area is 14.4 miles north of the dam. Both areas yielded a considerable quantity of the calcined product before 1928, when the mines were forced to close through competition from the the Kramer area in California. In both areas the colemanite occurs in the Horse Spring formation, of Tertiary (Miocene?) age, in beds a short distance stratigraphically above a very prominent ridgemaking limestone member of that formation. The colemanite in both areas is associated with beds of limestone, dolomite, and clay. Some of the limestone is very finely laminated, and in places there are numerous nodular masses ("goose eggs" or "eggshells") of concentrically laminated limestone, as shown in plate 4, *A*.

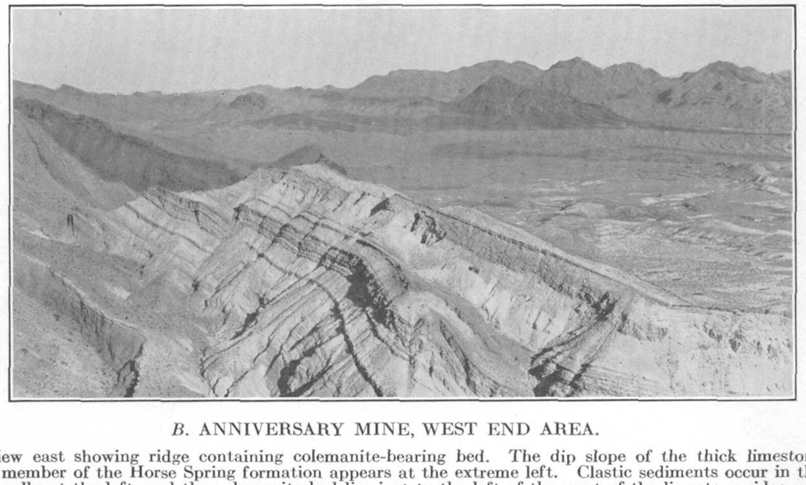
● *White Basin.*—The deposit in White Basin is about 20 miles by road southeast of Crystal station on the Union Pacific Railroad. Colemanite occurs here as lumps and crystal rosettes in calcareous clay with associated thin limestone beds. The colemanite-bearing beds are mostly less than 3 feet thick and dip gently to the north and northwest. They are broken by faults so that outcrops are discontinuous. Except for the limestone ridges, the relief within the basin is slight, and exposures are poor.

Considerable prospecting and some mining have been carried on. The Pacific Coast Borax Co. explored over 200 acres, and additional ground was worked by the American Borax Co. All mining operations have ceased, and the calcining plant has been dismantled. Undoubtedly large reserves remain.

● *West End.*—In contrast to that in White Basin, the deposit of colemanite at the Anniversary mine of the West End Chemical Co., in Callville Wash, is a well-defined steeply dipping bed in an extremely rugged area, as shown in plate 4, *B*. It is 26 miles by a private road east of the railroad at Lovell siding. The deposit was discovered in January 1921, and production started from the calcining plant on the property in July 1922. Operations ceased in 1928, but the camp, plant, equipment, and mine workings are still largely intact and in moderately good condition. No figures on production were obtained, but from the amount of underground work it is estimated that the total production was more than 100,000 tons of ore, which should have yielded about 25,000 tons of B_2O_3.

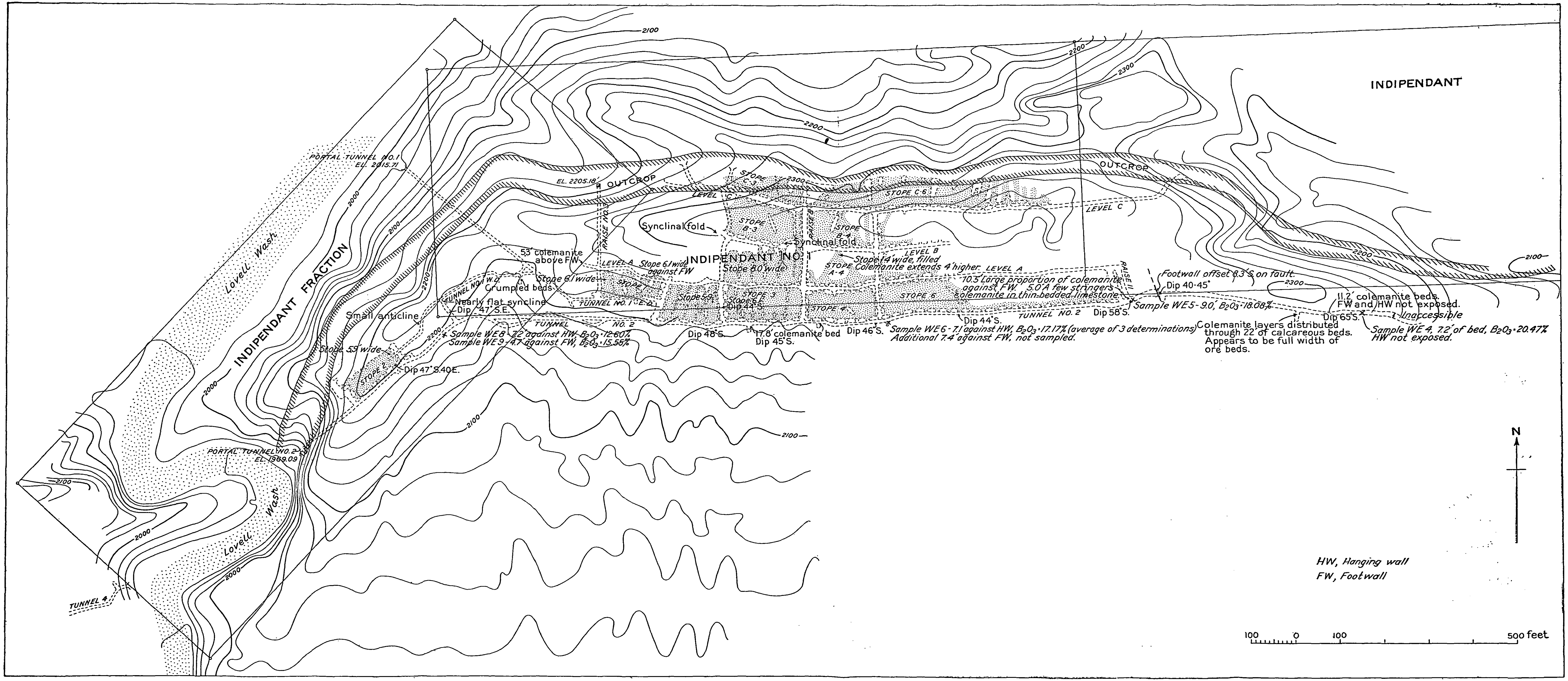
A. THE "EGGSHELL" BEDS, WEST END AREA, CLARK COUNTY, NEV.

Characteristic "eggshell" beds and large nodules or "goose eggs" which occur near the colemanite beds. One exceptionally large nodule shows the concentric structure.



B. ANNIVERSARY MINE, WEST END AREA.

View east showing ridge containing colemanite-bearing bed. The dip slope of the thick limestone member of the Horse Spring formation appears at the extreme left. Clastic sediments occur in the gully at the left, and the colemanite bed lies just to the left of the crest of the limestone ridge and is marked by the caved stopes. Tuffaceous beds occur in the low area in the middle distance at the right. Subordinate anticlinal fold in center of view.



TOPOGRAPHIC MAP SHOWING PLAN OF UNDERGROUND WORKINGS OF ANNIVERSARY MINE.

Furnished by West End Chemical Co., owner, with additional notes by W. W. Rubey and Eugene Callaghan.

The deposit occurs on the north side of a synclinal basin, which is outlined by the lode claims shown in figure 38. The axis trends approximately east-west. The thick limestone member of the Horse Spring formation makes high, rugged ridges on the north and west sides of the basin, but on the south side this limestone has been eliminated by faulting, and its place is taken by a ridge of Paleozoic and Mesozoic formations (Kaibab and Moenkopi). The syncline widens

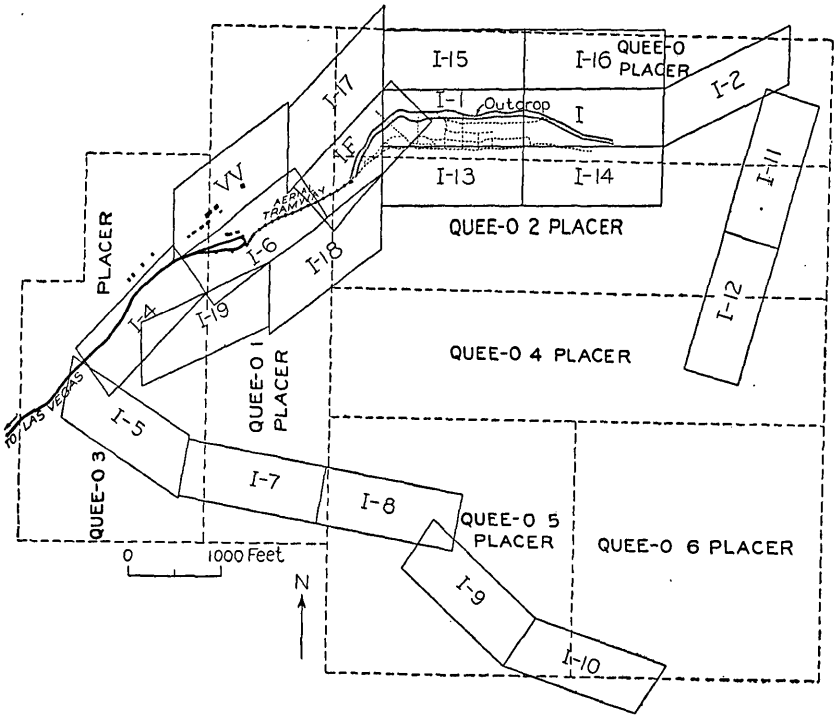


FIGURE 38.—Claim map showing Anniversary mine, camp, and calcining plant of West End Chemical Co., Clark County, Nev. Furnished by owners. The pattern of the lode claims indicates the curve of the outcrop around the west end of the syncline.

and becomes ill defined toward the east. As shown by plate 5, the colemanite bed crops out for 3,100 feet along the north side of a subordinate limestone ridge. The outcrop of the colemanite bed continues westward, but the colemanite itself essentially terminates at Lovell Wash, and only negligible quantities of the mineral are reported to have been found in the tunnel 500 feet to the southwest. The major part of the bed strikes east and dips 45°–65° S., but the west end turns southwest, toward the axis of the syncline. A very few minor faults interrupt the continuity of the bed, and there are several subsidiary anticlines and synclines, especially in the area of change in strike. The accompanying stratigraphic section, measured largely along Lovell Wash from a bed below the base of the thick limestone unit through to the center of the syncline, shows the stratigraphic environment of the colemanite bed and details within the bed. In general, the Horse Spring formation, considerably over 2,000 feet thick at this point, consists of a series of clastic beds at the base, succeeded by a thick limestone, a gypsiferous and clastic series, a calcareous clay and limestone unit that contains the colemanite bed, and finally a group of tuffaceous beds at the eroded top. Lateral variations are striking: the limestones become thinner along the outcrop toward the southwest, and on the south limb of the syncline the limestone that overlies the colemanite grades sharply into conglomerate on the east. The colemanite itself appears to end by grading out into other sediments, rather than by convergence of overlying and underlying beds.

Stratigraphic section of colemanite and associated beds near Lovell Wash, West End borate area, Clark County, Nev.

	Feet
Quaternary: Gravel	25.0
Angular unconformity.	
Tertiary: Horse Spring formation (partial section, 2,180 feet):	
Tuffaceous beds (580 feet):	
Tuffaceous sandstone	12.0
Tuffaceous shale, soft	50.0
Tuffaceous sandstone	30.0
Limestone, thin-bedded, with 7 thin cherty tuffs	29.0
Sandstones and shales alternating; some pink beds and 3 cherty beds	125.0
Tuffaceous sandstone, thin-bedded but weathers massive	51.0
Fanglomerate; large blocks of lower limestones in lower part; grades upward into tuffaceous sandstone	70.0
Tuffaceous sandstone, gritty, with Paleozoic limestone pebbles	9.4
Limestone, rough weathering surface	2.3
Tuffaceous sandstone, brown, gritty	36.0
Tuff, calcareous	.5
Tuff, bluish gray	2.3
Limestone and tuff; 3 feet of limestone at base	8.5
Limestone and tuff	16.4
Tuff, white	3.3
Tuff and calcareous tuff; thin limestone at top and bottom	3.9
Tuffaceous sandstone, thin-bedded; some pinkish layers	6.2
Tuff, white	13.4
Tuff, white; clay layers; 1.5 feet of limestone at top	4.4
Tuffaceous sandstone, gritty, massive, irregularly thin-bedded; clay layers 1.6 feet from top	18.5

Stratigraphic section of colemanite and associated beds near Lovell Wash, West End borate area, Clark County, Nev.—Continued

Tertiary: Horse Spring formation—Continued.	
Tuffaceous beds—Continued.	*Feet*
Tuff, white	1.2
Limestone; silt and grit in lower part	14.3
Limestone, wavy surface; calcareous concretions	2.4
Tuff, soft	1.2
Limestone, thin-bedded, wavy surface	3.2
Tuff, white, massive	.9
Tuff, calcareous, white and red, thin-bedded	2.0
Tuff, silicified and green at top and bottom, pink in middle	.8
Tuff, white, thin-bedded	5.7
Limestone, reddish brown, silty	1.5
Tuff, white at base; becomes brown and more calcareous toward top	3.2
Limestone and tuff, thin-bedded, gradational	8.7
Siltstone, calcareous, pinkish, tuffaceous	4.0
Siltstone, calcareous, brownish pink, soft weathering surface; biotite flakes; limestone pebbles, tuffaceous	17.7
Limestones (224 feet), subordinate ridge limestone:	
Limestone, thinly laminated but weathers massive; some crinkly beds and some silicified "eggshells"	117.0
Limestone, rough weathering, numerous faults; pink "eggshell" bed near top	37.0
Limestone, massive, buff, rough weathering; beds above and below truncated; crinkly at top	2.6
Limestone, thin-bedded, some highly contorted; some large "eggshells"; numerous ripple-mark layers	47.5
Limestone, thin-bedded; 2 conspicuous "eggshell" layers	5.5
Limestone, very thin bedded; ripple marks, "eggshells"	4.0
Carbonate, soft; numerous "eggshells"	2.5
Carbonate, white, hard	.9
Limestone, thin-bedded; "eggshells"	.9
Limestone, thin-bedded	1.5
Gypsum, with clay	.4
Dolomite, white; some pink	2.4
Carbonate beds, white; numerous gypsum layers	1.7
Colemanite bed (8.8 feet):	
Carbonate, thin-bedded, white; lenses and lumps of colemanite; also gypsum in gray and reddish clay	2.5
Clay, gray, with colemanite	.6
Carbonate, white	.2
Clay, gray, with colemanite and ulexite (?)	.7
Carbonate, white	.1
Clay, gray, with colemanite	.1
Carbonate, white	.15

Stratigraphic section of colemanite and associated beds near Lovell Wash, West End borate area, Clark County, Nev.—Continued

	Feet
Tertiary: Horse Spring formation—Continued.	
Colemanite bed—Continued.	
Colemanite with a little clay	0.8
Carbonate, white, laminated	.4
Clay, gray, with colemanite	.7
Calcite, white; a little gypsum	.1
Clay, gray, abundant colemanite; "eggs" irregularly distributed	1.7
Tuff, brown, poorly sorted, biotite, some clay	.05
Carbonate, white; clay, contains some colemanite	.1
Clay, gray	.1
Clay, reddish, colemanite	.5
Limestone with argillaceous beds; abundant "eggshells" (225 feet):	
Carbonate and red calcareous clay	1.0
Calcareous clay, white carbonate beds; numerous satin-spar gypsum veins	11.0
Calcareous clay; softer weathering surface than that below	3.6
Calcareous clay; "eggshell" beds; ripple-mark layers 6.5 feet above base; a few red stains	7.8
Carbonate rock, thin-bedded, pink; "eggshells"	5.8
Calcareous siltstone, laminated; weathers massive	2.2
Calcareous clay, yellowish gray and reddish; "shell" layers	5.3
Calcareous clay, soft weathering surface; pellets in lower 2.7 feet, pink; "eggshells"	6.1
Limestone and calcareous clay, pink and white; "eggshells" at base	6.4
Limestone, three layers, alternating with three clay layers	4.8
Limestone, hard, buff, with clay interbedded	9.3
Calcareous clay and carbonate beds, contorted, tan, pink, and light gray; thickens to 5.2 feet in short distance	1.0
Carbonate and calcareous clay, crinkly layers; "eggshells" in middle; white beds at top	15.6
Limestone, hard, resistant, laminated	16.3
Limestone, thin-bedded, crinkly	1.2
Limestone, buff, laminated	4.4
Limestone, buff, granular; grades into thin-bedded; "eggshell" layers near top	6.7
Limestone, white, thin-bedded, not resistant	1.5
Limestone, thin-bedded, resistant, conspicuous; numerous "eggshells"	8.0
Limestone, hard, crinkly at base, soft beds, white to pale buff; some "eggshell" beds	12.6
Limestone, soft, white, with pinkish partings; "eggshells"	6.0
Limestone, hard, granular, fragmental; some thin-bedded layers in upper part	4.2

Stratigraphic section of colemanite and associated beds near Lovell Wash, West End borate area, Clark County, Nev.—Continued

Tertiary: Horse Spring formation—Continued.	
Limestone with argillaceous beds—Continued.	*Feet*
Limestone; abundant "eggshells"; some fragmental layers	3.2
Limestone, thin-bedded, white; pink clay laminae; "eggshell" beds	9.6
Limestone, pink and gray, 3 crinkly beds, 2 white beds; "eggshells" in upper 0.5 foot	6.8
Calcareous clay with white carbonate beds, greenish layers	16.0
Calcareous clay, greenish gray, soft weathering surface; abundant gypsum crystals in upper third	1.6
Carbonate beds, soft, white	6.0
Limestone, buff-gray; yellowish hard layers 0.4–0.8 foot thick, with clayey layers	13.6
Limestone, crinkly, white, thin-bedded; soft gray clayey beds; "eggshells" 0.65 foot above base	2.7
Siltstone, massive, buff and gray	4.0
Carbonate beds, white, with clayey and silty beds	8.6
Calcareous clay, greenish gray, slightly gritty	1.0
Calcareous siltstone; numerous cavities in hard silty bed	7.8
Calcareous siltstone, thin-bedded, pinkish buff to yellowish; 0.1-foot gypsum bed 1.7 feet above base	3.7
Red and variegated silts and shales with gypsum (366 feet):	
Siltstone, red, clayey and calcareous	23.0
Siltstone, thinly laminated but weathering massive	9.1
Shales, red, with massive siltstone	18.0
Massive siltstone with a little red shale	7.0
Shales, red, and hard siltstones in alternating beds	14.3
Calcareous clay, light buff to gray; more argillaceous at middle and base	9.0
Shale, pinkish; medium-gray silt beds	4.5
Clay, silty, pink and greenish	4.0
Gypsum, argillaceous	1.4
Clay, yellow	6.1
Satin-spar gypsum, very conspicuous and continuous	.4
Yellow clay	.9
Clay, pink, with 2.5 feet massive siltstone in center	5.3
Gypsum beds, 0.05 to 0.02 foot thick, with yellow clay and calcareous beds	3.0
"Eggshell" bed	.2
Siltstone, red, lithographic texture	45.0
Shale, green	11.0
Gypsum	1.8
Shale, tan	6.0

Stratigraphic section of colemanite and associated beds near Lovell Wash, West End borate area, Clark County, Nev.—Continued

	Feet
Tertiary: Horse Spring formation—Continued.	
Red and variegated silts and shales with gypsum—Con.	
Shale, bluish green, conspicuous	4.5
Clay, brown	7.2
Gypsum beds, crinkled, with gray shale; 1.5 feet of red shale 3 feet below top; changes to limestone to north	61.0
Siltstone, tan, with 2 feet of purple clay at top	11.7
Red siltstones; some sandy beds; some shale; numerous ripple marks	67.5
Gypsum layers and red siltstones	2.5
Siltstones, red	6.9
Limestone with variegated shales	2.5
Limestone, thin-bedded, with shale layers; "egg-shell" bed 5.5 feet below top	15.0
Shales, red, thin-bedded, and thin-bedded limestone	17.4
Prominent ridge-making limestone (776 feet):	
Limestone, thinly laminated but massive. Exposed areas contain peculiar circular ridges, interpreted as possible algal reefs. Some are partly silicified	116.0
Tuff	4.4
Limestone	90.0
Tuff	6.1
Limestone; some calcareous clays in lower 5 feet	560.0
Red siltstones and gray tuffs; base not exposed	200+

Conditions favorable to underground mining are the continuity of the bed, its average thickness of 8 feet or more for much of its length, a dip of 45° to 65°, and a maximum relief above Lovell Wash of 370 feet measured vertically or 560 feet measured down the dip (pl. 5). The lowermost or no. 2 tunnel follows the bed for 2,700 feet from the portal on the east bank of Lovell Wash. The innermost 70 feet of this tunnel was not accessible at the time of examination. Level 1 is 45 feet vertically higher and is reached by a crosscut 390 feet long from the northwest. Above this are drifts A, B, and C, of which drift C reaches the surface at both ends. In all, there are about 6,500 feet of drifts and nearly 500 feet of crosscuts. Raise 8 extends 470 feet to the surface from tunnel 2, and there are three other long raises and numerous stopes, as shown in plate 5.

The colemanite-bearing bed contains other material also—calcareous clay beds, thin beds of limestone and dolomite, and parallel seams or veinlets of gypsum. The mineral constituents, calculated from the analysis given by Gale, are colemanite 42 percent, gypsum 2.5 percent, dolomite 27 percent, and silicates 28.5 percent. The silicates are probably in large part clay minerals and volcanic materials. In the channel samples taken by the writers across the colemanite bed on level 2, the B_2O_3 ranged from 12.60 to 20.47 percent, corresponding to 25 to 40 percent of colemanite. Fragmentary records at the mine indicated that the B_2O_3 content of the mill heads ranged from 19.5 to 24 percent for the short period of the record. Calcines contained an average of 42 percent of B_2O_3, and an average of 3 percent was lost in the tailings.

Calculations based upon plate 5 indicate that the surface of the colemanite bed above tunnel 2, mirror irregularities being neglected, is 1,033,000 square feet. Of this area 305,000 square feet, or about 30 percent of the total, represents the stopes. The width of the stopes ranges from 5.9 to 15 feet and averages about 8 feet. If 8 feet is the average stope width or bed thickness found feasible to mine, it may be assumed as the average minable thickness for the entire deposit. On this basis about 5,824,000 cubic feet, or, at a rock density of 2.2, about 400,000 short tons of ore still remains. Actual measurements of the full thickness of the bed range from 8.8 to 22 feet. If the average full thickness of the bed is about 15 feet, the total reserve is nearly twice that given, but this larger reserve is presumably of lower grade. In these estimates no account has been taken of ore below tunnel 2. Ore below this level would possibly double the reserves, but its recovery would involve higher mining costs.

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MAGNESITE AND BRUCITE

By W. W. Rubey and Eugene Callaghan

The principal magnesium minerals are magnesite (Mg, 28.8 percent; MgO, 47.6 percent), brucite (Mg, 41.6 percent; MgO, 69.0 percent), dolomite (Mg, 12.6 percent; MgO, 21.7 percent), and magnesium chloride (Mg, 25.5 percent in the anhydrous form, 12 percent in the hydrous form). Magnesium chloride obtained from brines has been the principal source of metallic magnesium, but other magnesium products have been obtained mainly from magnesite. However, magnesite has also been used as an ore of metallic magnesium, particularly in Europe.

Commercial deposits of magnesite occur in three principal forms—(1) as extremely fine-grained veins and masses associated with serpentine, as in the Coast Ranges of California; (2) as "crystalline" or marblelike masses formed by replacement of dolomite or calcite beds by magnesian solutions, such as the deposits in Stevens County, Wash., and the deposits at Paradise Range, Nye County, Nev.; and (3) as sedimentary deposits in which magnesite occurs in nonmarine strata interbedded with dolomite, clay, and other detrital materials. Sedimentary magnesite is very fine grained, commonly contains dolomite, clay, or detrital impurities, is white or faintly colored, and in some localities breaks down in water and swells like bentonite. Only one deposit of this type, that at Bissell, Calif., has been worked commercially. All but one of the known sedimentary deposits in the Boulder Dam region were visited during this investigation. The large deposits of magnesite and brucite in the Paradise Range, Nev., were mapped by Callaghan in 1931 and 1933.

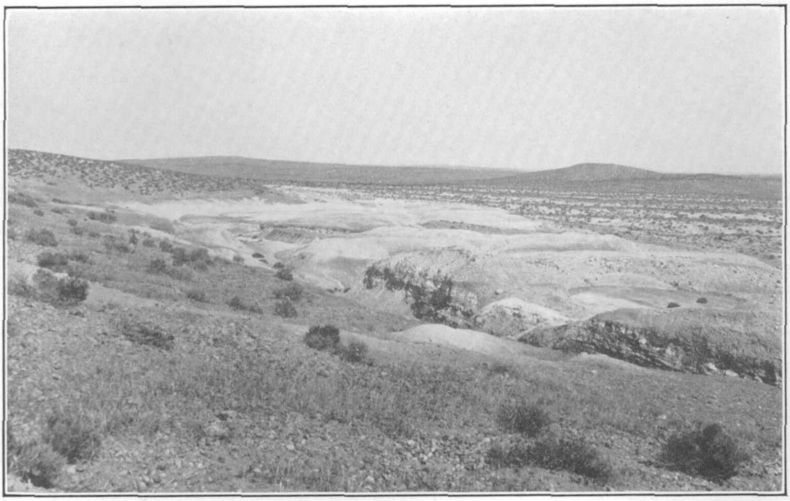
At the outset of this investigation it appeared that large resources of magnesite favorable to the establishment of a magnesium metal industry in the vicinity of Boulder Dam were available. This was particularly true of the deposit near Overton, Nev., a short distance from the dam. Consequently, the Overton deposit was subjected to detailed geologic investigation, sampling, and chemical analysis, and though the quality of the material was not as high as had been hoped, it is deemed advisable to publish the detailed information for the benefit of possible future operators. A proper understanding of the geologic setting and origin of these deposits is necessary to working out plans for their extraction and treatment. Therefore, the Overton deposit is given more extended treatment in this report than other deposits or mining districts.

Broadly stated, the sedimentary deposit at Overton is large but of low grade, though its proximity to the dam may make it attractive if the metallurgical problems can be solved. The deposits of the "crystalline" type of magnesite and brucite in the Paradise Range are of high grade and very large but are remote (262 miles in a direct line) from the dam.

CALIFORNIA

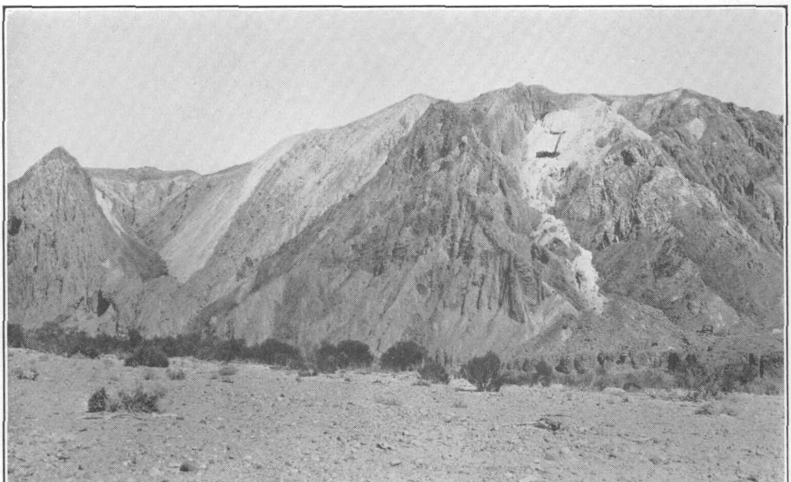
KERN COUNTY

● *Bissell.*—Bedded magnesite occurs on the south slope of a low ridge (pl. 6, *A*) in the northeastern part of sec. 11, T. 10 N., R. 11 W., slightly less than a mile northeast of Bissell station on the Atchison, Topeka & Santa Fe Railway and 10.3 miles by road east of Mojave. According to Gale, it was discovered in 1911 and is the only sedimentary deposit that has been worked commercially. The Southern Pacific Co., owner of the property, states that it yielded 6,625 tons in 1915, 7,687 tons in 1916, 1,135 tons in 1917, 284 tons in 1918, and



A. PART OF THE QUARRIES ON *THE BEDDED MAGNESITE DEPOSIT* NEAR BISSELL, KERN COUNTY, CALIF.

The quarry at the right is about 30 feet deep and 20 to 60 feet wide at the bottom. The magnesite occurs as thin white beds in dark silty clays. Note the gentle slopes of the low hills in the Mojave Desert.



B. MAGNESITE MINE, AFTON AREA, SAN *BERNARDINO COUNTY*, CALIF.

Deposit of bedded magnesite in canyon between Afton and Baxter stations. The magnesite is marked by the conspicuous white outcrop at the right center. It is underlain by a thin irregular conglomerate resting upon black schist and is overlain by thick red conglomerate to the left (east). A conspicuous syncline appears at the left. Bed of Mojave River in foreground.

26 tons in 1923, a total production of 15,757 tons. The deposit was worked by means of shallow quarries, as shown in plate 6, *A*, and figure 39, for an over-all length of 3,800 feet. The thin overburden was removed by scraper, and the white magnesite was separated from the clays by hand. Underground work was started from a shaft 100 feet deep in the hanging wall in the western part, and some crosscuts and raises were excavated, but all this work has been abandoned.

The magnesite occurs as a group of thin white beds (mostly less than 1 foot thick) with dark silty clay interbeds, in a thick series of sediments regarded by Simpson as of middle Miocene age. The magnesite zone ranges in thickness from a few feet to as much as 75 feet, as shown in the stratigraphic section below. The entire formation strikes roughly east, as shown in figure 39. The dip is chiefly between 20° and 60° S., but both dip and strike are extremely variable within small areas. Not only are there irregularities in the strike of the formation as a whole, and possibly some minor faults, but the soft magnesite and associated clays are in places greatly contorted and broken, in much the same way as some of the beds in the deposit near Overton, Nev.

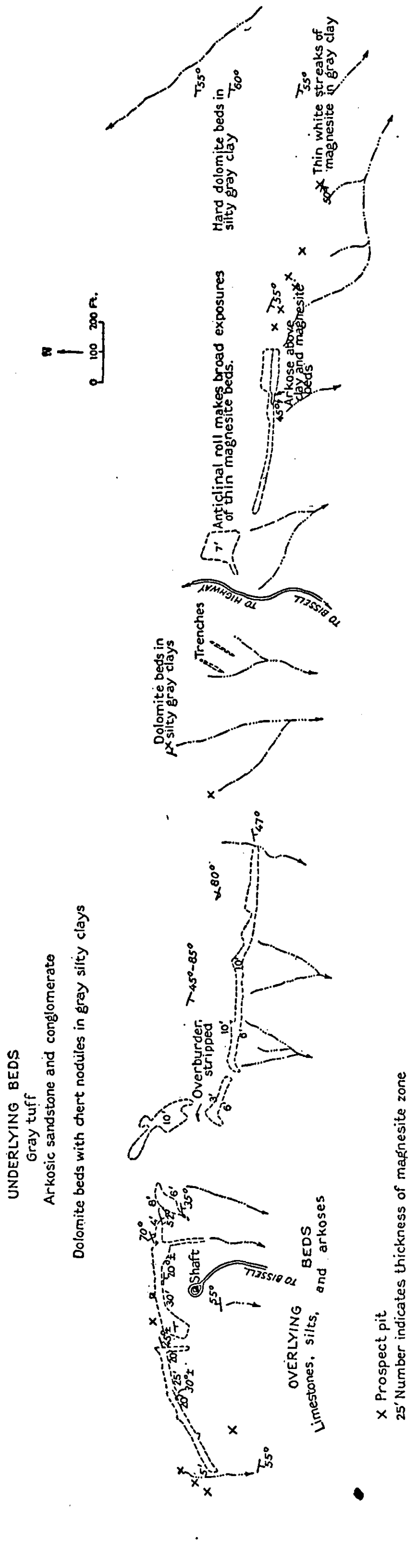


FIGURE 39.—Sketch traverse showing extent of the open quarries (broken lines) in the magnesite deposit near Bissell, Kern County, Calif. Figures indicate depth of quarry. Broad quarries indicate anticlinal rolls in the southward-dipping beds.

Generalized stratigraphic section of rocks exposed from a point about 500 feet north to a point about 500 feet south of magnesite workings, Bissell, Kern County, Calif.

	Feet
Top not exposed nearby.	
Gritty sandstone, calcareous shale, cherty limestone and dolomite, and arkosic conglomerate	150±
Magnesitic clays, dominantly pale-gray soft clay with thin hard beds of magnesite and dolomite. Some of the clay is dark brown, owing to the presence of plant fragments; some greenish-gray clay is biotitic and tuffaceous	75±
Arkosic sandstone and gritty clay	10–25
Hard cherty limestone and dolomite and soft gray calcareous shale. Limestone beds 1 to 3 feet thick; shale beds 10 to 25 feet thick. Unit forms prominent ridge	150–200
Arkosic sandstone, clay, and conglomerate	75±
Tuff, pale gray, with abundant biotite flakes	10+
Base not exposed.	

The proportion of magnesite within the best part of the magnesite zone is variable but roughly 50 percent. In a section of 17.4 feet measured by the writers in the easternmost quarry nine magnesite beds have an aggregate thickness of 9.0 feet. In one section made by Gale six beds of magnesite have an aggregate thickness of 4 feet 7 inches in a total of 7 feet 3 inches of beds. In another section, five beds of magnesite have an aggregate thickness of 1 foot 6 inches in a total of 4 feet 3 inches of beds. No new analyses of this magnesite were obtained by the writers. The first four given in the table below were made by J. G. Fairchild in the laboratory of the United States Geological Survey and are quoted from Gale; the remainder were made by Mark Walker and have been furnished through the courtesy of the Southern Pacific Co.

Analyses of magnesite from deposits near Bissell, Calif.

SiO_2	9.64	8.51	6.03	4.75	10.60	10.33	10.05	8.42
Al_2O_3	} 2.46	2.94	1.40	.76	6.10	6.17	} 10.05	3.27
Fe_2O_3					.86	.68		
MgO	37.19	38.32	42.78	44.20	33.56	34.65	31.58	38.90
CaO	4.25	3.36	1.56	Trace	4.90	3.58	1.22	1.70
CO_2	40.70	40.12	45.78	47.32				
Undetermined	5.76	6.75	2.45	2.97				
	100.00	100.00	100.00	100.00				
SiO_2	4.99	5.15	9.45	6.78	8.74	7.64	7.05	5.91
Al_2O_3 and Fe_2O_3	2.55	1.69	2.68	1.56	2.78	1.42	1.35	2.92
MgO	41.30	42.95	40.48	42.80	40.44	42.74	42.42	41.80
CaO	2.73	.69	2.01	1.81	2.76	1.69	2.19	1.07

Analyses of calcines

[Mark Walker, analyst]

SiO_2	12.68	16.41	17.61	12.88	12.68
Al_2O_3 and Fe_2O_3	8.26	2.81	3.01	4.68	8.26
MgO	72.26	70.81	72.75	75.87	72.26
CaO	5.26	6.41	5.41	3.48	5.26

The outcrop length of about 4,200 feet indicates large reserves. It may be assumed for the purpose of a rough estimate that the better part of the magnesite averages 10 feet in thickness for the length of the quarries, about 2,800 feet. On the basis of a rock density of 2.2 and an aggregate thickness of workable magnesite of 5 feet for a depth of 100 feet down the dip, the estimated reserves would be about 100,000 tons. Probably a much larger amount might be recovered. Most of the material that can be readily obtained from open quarries with a minimum of stripping has been taken. Any future extensive operations must use underground methods of extraction, and the steep dip carries the bed to considerable depths in a very short distance. All material would have to be hoisted from shafts, as the relief is too low to permit operations from adits.

The deposits are described in the following publications:

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SAN BERNARDINO COUNTY

● *Afton.*—A deposit of bedded magnesite occurs on the south side of Cave Canyon of the Mojave River, 1½ miles southeast of Afton, 3½ miles west of Baxter, and about 2,000 feet from the tracks of the Union Pacific Railroad. White and pink fine-grained carbonate rock of variable thickness, but largely from 30 to 40 feet, crops out for a horizontal distance of 400 to 500 feet in the rugged canyon wall that rises about 500 feet above the bed of the river. The carbonate rock appears to be near the base of a folded and faulted series of rocks of probable Tertiary age and dips steeply north. It is underlain by a red bouldery silt and a thin basalt flow, which in turn rest upon black schistose rock. It is overlain by a thick red conglomerate, which is folded in a syncline, as shown in plate 6, *B*.

The deposit appears to have been discovered prior to 1918, and an aerial tramway was constructed from a point about halfway up the slope to the railroad. Only the cables remain, and very little development work was done. Underground mining would be necessary to extract most of the deposit.

Analyses of channel samples taken by the writers, representing 18.3 feet of beds exposed in the principal old workings, are given below, together with three analyses quoted from Bradley. The analyses indicate that only 6.8 feet of these beds contain more than 30 percent of MgO. A lump sample from a separate exposure of white carbonate rock on the upland about 1,000 feet to the east was found to be dolomite.

Analyses of magnesite from deposit near Afton, Calif.

	AM1	AM2	AM3	AM4	AM5	AM6	AM7	1	2	3
Insoluble in ¼ HCl	12.2	7.3	14.4	17.5	26.4	16.6	5.1	--------	--------	--------
SiO_2	--------	--------	--------	--------	--------	--------	--------	10.14	10.12	10.10
Al_2O_3	--------	--------	--------	--------	--------	--------	--------	4.40	3.69	1.73
Fe_2O_3	--------	--------	--------	--------	--------	--------	--------	.78	.67	1.41
MgO	20.6	35.6	29.5	30.9	20.0	33.5	20.3	36.48	35.62	38.19
CaO	24.4	7.8	11.1	6.6	14.5	4.7	28.3	1.74	3.36	3.10
CO_2	--------	--------	--------	--------	--------	--------	--------	--------	--------	40.65
Ignition loss	--------	--------	--------	--------	--------	--------	--------	45.68	45.80	--------
Alkalies	--------	--------	--------	--------	--------	--------	--------	.86	.88	--------
Total	--------	--------	--------	--------	--------	--------	--------	100.08	--------	95.18

AM1 to AM7 analyzed by J. G. Fairchild; 1, 2 by Smith, Emery & Co.; 3 by Sill & Sill.
AM1. Tough pinkish carbonate rock, 3.5 feet thick, at south end of old quarry face.
AM2. Hard, white carbonate rock, 1.0 foot thick, above AM1.
AM3. Hard white and pinkish carbonate rock, 5.0 feet thick, at north end of old quarry face.
AM4. Moderately hard white carbonate rock, 3.0 feet thick, above AM3.
AM5. Soft purplish clayey carbonate rock, 3.0 feet thick, above AM4.
AM6. Hard white carbonate rock, 2.8 feet thick, above AM5.
AM7. Hard white carbonate rock in separate exposure about 1,000 feet east-southeast of old quarry. Lump sample.

At an estimated average thickness of about 13 feet of magnesite, it appears that there is above the level of the canyon floor between 100,000 and 200,000 tons of ore with a MgO content of 30 percent or more.

References for this deposit are as follows:

Hamilton, Fletcher, California State Min. Bur. Rept., vol. 17, pp. 353–354, 1921.

Bradley, W. W., Magnesite in California: California State Min. Bur. Bull. 79, pp. 72–75, 1925.

Tucker, W. B., and Sampson, R. J., San Bernardino County: California State Min. Bur. Rept., vol. 27, p. 390, 1931.

Cima.—A small deposit of magnesite occurs 12 miles northeast of Cima, a station on the Union Pacific Railroad, and is reached by a desert road. It is reported that 125 tons of ore has been shipped from this deposit to Los Angeles. The deposit has been developed for 500 feet along the strike and to a depth of 80 feet, according to Tucker and Sampson. According to Hewett, who examined this deposit in 1929, the magnesite occurs as a well-defined layer 1 to 3 feet thick between good walls in Paleozoic dolomites. The bedding of the dolomite strikes N. 55° W. and dips 40° SW., whereas the magnesite layer strikes N. 70° W. and dips 35° SW., following a fracture that crosses the dolomite at a low angle. The material is nearly pure white, very fine grained, dense, and in parts faintly fibrous. No data on reserves are available, but they are probably small. The following references may be given:

Tucker, W. B., and Sampson, R. J., San Bernardino County: California State Min. Bur. Rept., vol. 27, no. 3, p. 390, 1931.

Hewett, D. F., Geology and ore deposits of the Ivanpah quadrangle: U. S. Geol. Survey Prof. Paper — (in preparation).

OTHER CALIFORNIA DEPOSITS

Reported occurrences of magnesite other than those described were recorded by Gale but apparently were either proved not to be magnesite or have been forgotten. Bradley records a reported occurrence of magnesite in the Providence Mountains, south of Cima, but this location is unconfirmed.

Yale, C. G., and Gale, H. S., Magnesite: U. S. Geol. Survey Mineral Resources, 1913, pt. 2, pl. 1, 1914.

Bradley, W. W., Magnesite in California: California State Min. Bur. Bull. 79, p. 75, 1925.

NEVADA

CLARK COUNTY

● OVERTON DISTRICT

Notable reserves of magnesite near the Muddy River in Clark County, Nev., have been known since 1915, when the area was visited by H. S. Gale, of the Geological Survey.[73] The magnesite crops out in the walls of two washes a mile apart in sec. 2, T. 17 S., R. 67 E., and secs. 34 and 35, T. 16 S., R. 67 E., about 5 miles south-southwest of Overton and 3 miles southwest of the St. Thomas branch of the Union Pacific Railroad. (See fig. 40 and pl. 7.) The mineral is nearly pure white, very fine grained, and strikingly claylike in its physical properties; it occurs interbedded with a unit of white clayey dolomite, 155 to 325 feet thick, which in general appearance is almost indistinguishable from the magnesite. Considerable prospecting has been done, and the area of known magnesite deposits is covered by both lode and placer claims; but no shipments of commercial material have been made.

General geology.—The magnesite deposits near Overton lie on the northeast side of the Muddy Mountains. The geology of this region is well described by Longwell.[74] The Muddy Mountains are composed of complexly folded and faulted sedimentary rocks of Cambrian to Jurassic (?) age. In the lower country immediately

[73] An immense deposit of magnesite in southern Nevada: U. S. Geol. Survey Press Mem., 1916. Yale, C. G., Magnesite: U. S. Geol. Survey Mineral Resources, 1915, pt. 2, p. 1024, 1916.

[74] Longwell, C. R., Geology of the Muddy Mountains, Nev.: U. S. Geol. Survey Bull. 798, 1928.

surrounding the mountains these older rocks are overlain unconformably by the Overton fanglomerate and Horse Spring formation, and these two formations are in turn overlain with sharp angular unconformity by the nearly flat-lying Pliocene (?) Muddy Creek formation and by later (Quaternary) deposits. The magnesite near Overton occurs as a sedimentary deposit in the lower part of the Horse Spring formation.

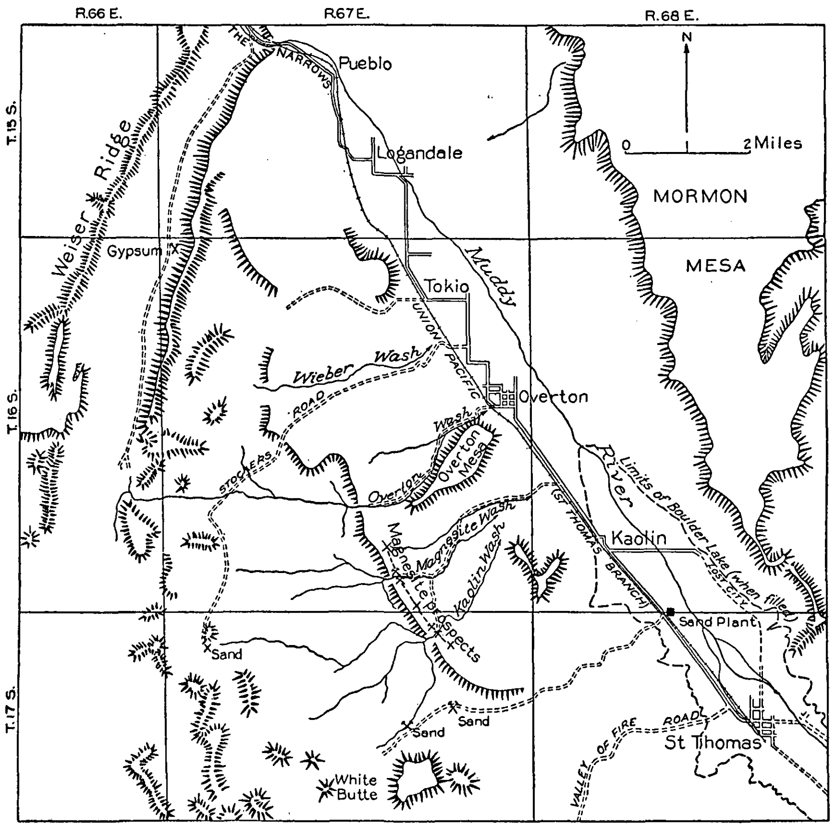


Figure 40.—Map of the Overton area, Nevada, showing location of magnesite, sand, and gypsum deposits.

The Overton fanglomerate near Overton consists of a lower unit of conglomeratic sandstone with subordinate clay and an upper unit of coarse limestone conglomerate. The lower sandstone unit thickens southward from 1,000 to 3,000 feet [75] within a distance of 8 miles, and the upper conglomerate unit thickens northward from less than 100 to 1,000 feet within the same distance.

The Horse Spring formation overlies the Overton fanglomerate conformably and with apparent gradation. Near the magnesite deposits the Horse Spring consists of (1) a lower unit of yellow

[75] Longwell, C. R., op. cit., pp. 69–70.

siltstone 65 to 115 feet thick, (2) a carbonate unit (which contains the white magnesite and dolomite beds) about 155 to 325 feet thick, (3) a red siltstone unit from 310 to more than 850 feet thick, and (4) the highest beds exposed beneath the overlapping Pliocene (?), a limestone conglomerate from less than 125 to more than 390 feet thick. As in the Overton fanglomerate, the finer-grained units (the yellow siltstone, the carbonate, and the red siltstone) thicken southeastward, and the conglomerate unit thickens northwestward along the outcrop. (See pl. 8.)

The age of the Overton and Horse Spring formations is not definitely known, although they have been and still are classified as Tertiary (Miocene?). Both formations are almost entirely unfossiliferous. The lower yellow siltstone unit of the Horse Spring in Kaolin Wash contains abundant cylindrical tubes that may be casts of worm holes or of tree roots. The writers found definite plant remains in fine-grained layers in the lower unit of the Overton fanglomerate at four localities in the Overton region and in the Horse Spring formation at one locality near Horse Spring, 25 miles to the southeast. These collections were examined by R. W. Brown, who reports that two of the four from the Overton and the one from the Horse Spring contain fragments of coniferous wood and monocotyledonous leaves, but that these remains afford no definite information about the age of the beds. However, the other two collections from the Overton appear more significant, and Mr. Brown's report on them is given herewith:

Collection A: Silicified and carbonized wood. Basal part of lower unit of Overton fanglomerate. From bed of gray clay, 100± feet thick, which here overlies a basal conglomerate unconformable on Jurassic (?) sandstone. Half a mile east of White Butte, 6 miles southwest of Kaolin, Nev.:

Tempskya sp.

Coniferous and dicotyledonous wood, species not identified.

The fern genus *Tempskya* is thought to be restricted to rocks of Cretaceous age, and the *Tempskya* sp. is known only from the lower part of the Upper Cretaceous in Wyoming and Idaho.

Collection B: Leaf impressions. Near middle of lower half of Overton fanglomerate. From bed of tuffaceous silt. Prospect pit of Spartan Silica Co., near small molding-sand quarry, 5 miles southwest of Kaolin and 5¾ miles due west of St. Thomas, Nev.:

Equisetum sp.

Microtaenia paucifolia (Hall) Knowlton.

Unidentifiable fragments.

The *Microtaenia paucifolia* specimens are a fern species found also in the Aspen and Frontier formations but so far not reported from any other geologic horizon.

The outstanding fossils from the Overton are two ferns, *Tempskya* sp. and *Microtaenia paucifolia*. These fossil species have not yet been reported from any horizon except the lower to middle portion of the Upper Cretaceous.

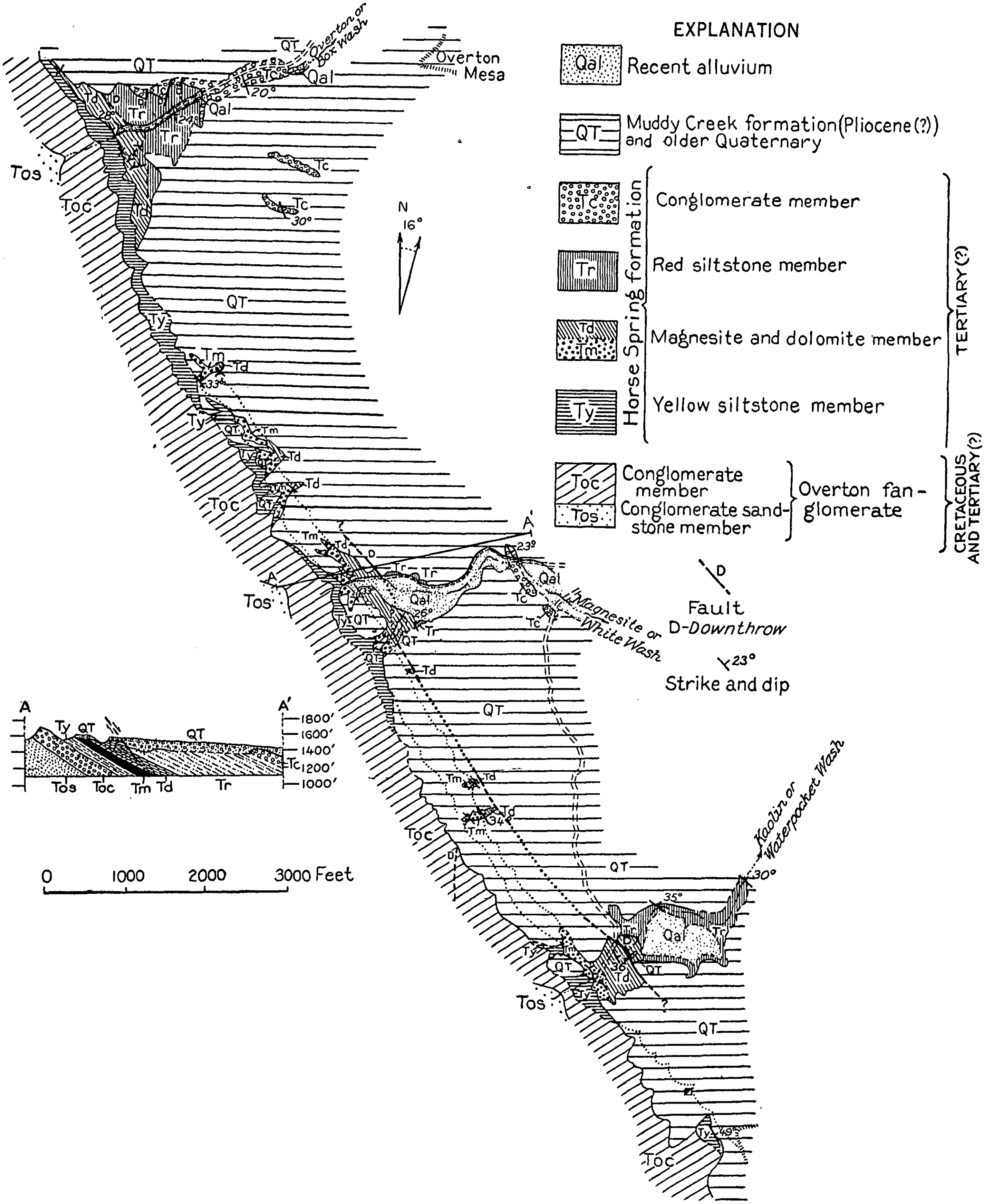
No other fossils have been recorded from the Overton or the Horse Spring formation, but it appears unnecessary to assign both formations or even the entire Overton fanglomerate to the Upper Cretaceous solely on the basis of these two collections. Elsewhere in Nevada and California beds of Miocene age carry magnesite and borates, and it is possible that the early assignment of the Horse Spring and Overton to Miocene (?) Tertiary is at least partly correct and that a significant unconformity will be found to lie within the rocks now classified as Overton fanglomerate.

Magnesite deposits.—In the general vicinity of the magnesite deposits the Horse Spring and Overton formations dip 25°–40° NE., away from the Muddy Mountains, and are overlain with sharp angular unconformity by nearly flat-lying gravel, sand, and silt of Pliocene (?) and Quaternary age. (See pls. 7 and 9.)

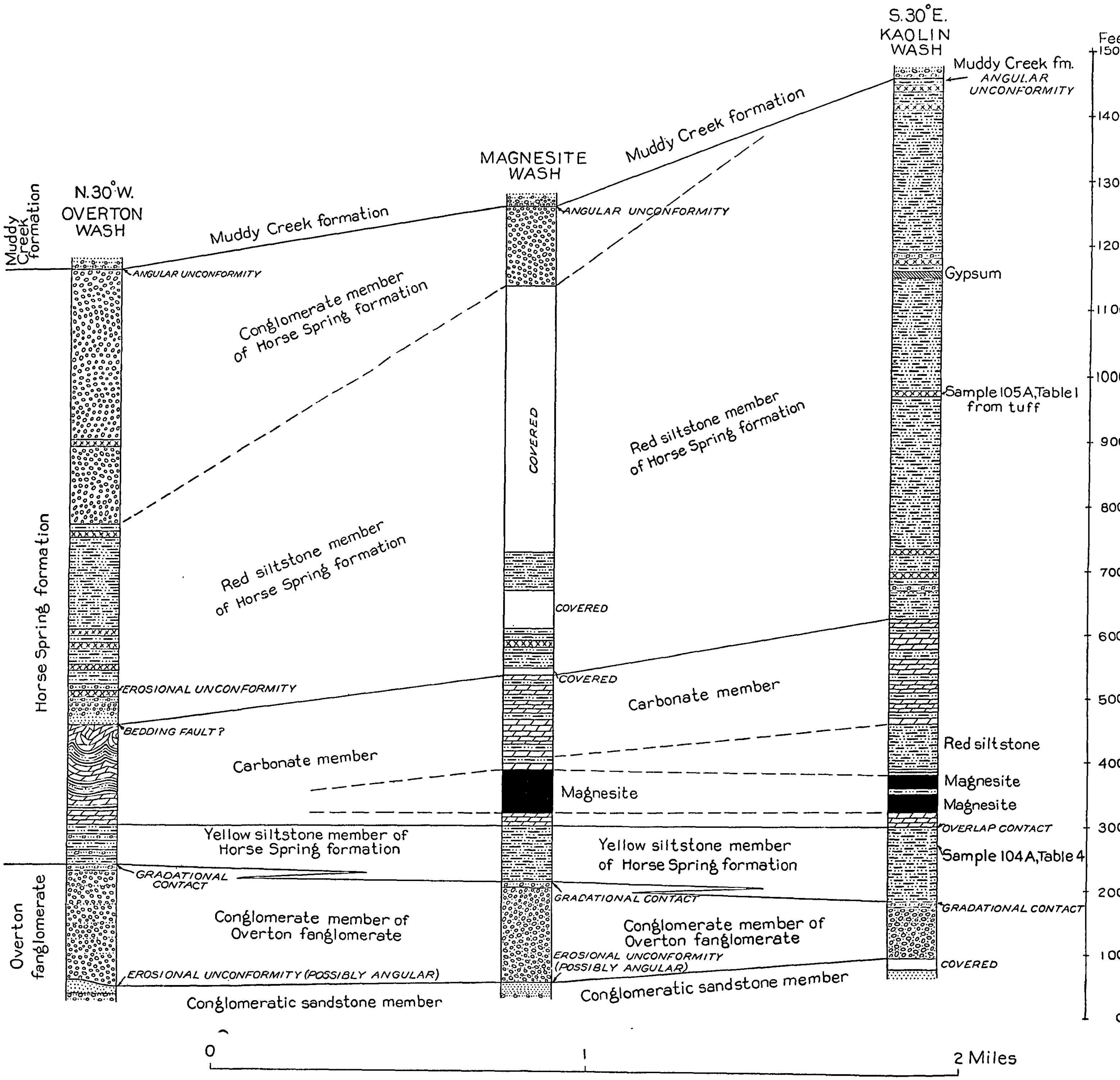
The carbonate member of the Horse Spring formation, which contains the beds of magnesite, consists chiefly of glaringly white, thinly laminated, rather claylike rocks. These white carbonate rocks are faintly tinged with pale-gray, pinkish, and greenish tints; and thin layers of green and red clay and thicker beds of red siltstone recur throughout the member. It is extremely difficult to distinguish the more magnesitic from the more dolomitic and clayey layers; but in general the purer magnesite layers are whiter and more massive, and tend to break with a more conchoidal fracture. Both carbonates and clays are exceedingly fine-grained, and in their general appearance they resemble dense white flint clay rather than ordinary carbonates. The peculiar claylike physical property of these rocks is shown not only by weathering surfaces and by ready slacking when immersed in water but also by the extreme contortion with which the beds have yielded to deformation where cut by minor faults and by sliding surfaces (pl. 9, *C*).

Field examination of the magnesite deposits consisted largely of detailed taped measurements of the individual beds that make up the carbonate member and the collection of numerous samples for chemical analysis. (See pls. 10 and 11.)

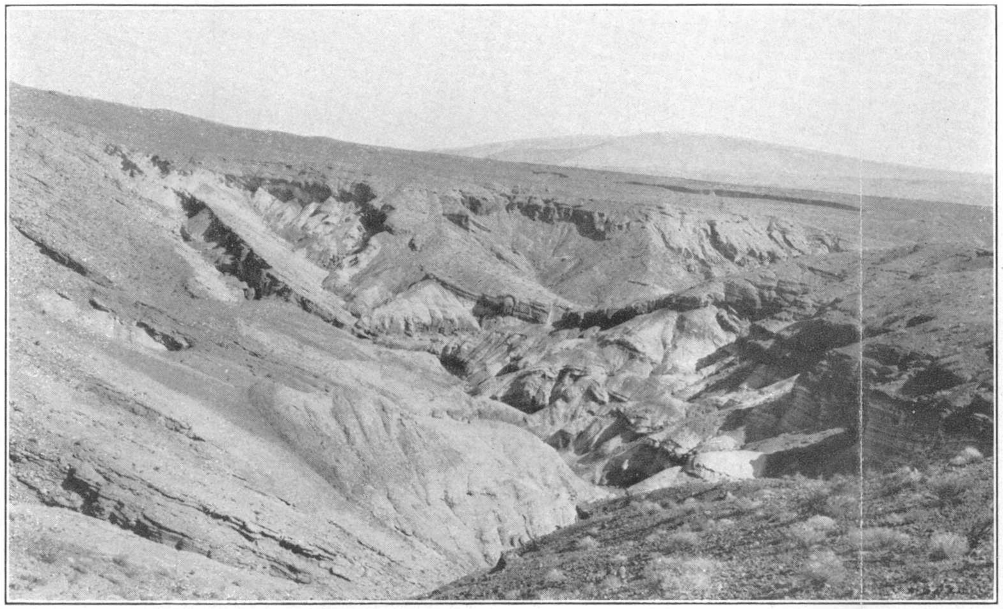
Inasmuch as the commercial possibilities of this magnesite deposit depend largely upon minor details of chemical composition, the representativeness of the samples chosen and the reliability of the analyses have critical importance. Two kinds of samples were collected—(1) channel samples, cut across a fresh rock face, crushed, and then systematically quartered down, to represent beds from 2 to 8 feet (usually 4½ to 6 feet) thick; (2) lump samples, collected by choosing large fragments to represent beds from 0.1 to 2 feet (usually 6 inches) thick. In all, 69 channel and 38 lump samples were collected. These samples were analyzed in the chemical lab-



MAP SHOWING DISTRIBUTION AND STRUCTURE OF MAGNESITE DEPOSITS SOUTHWEST OF OVERTON, NEV.

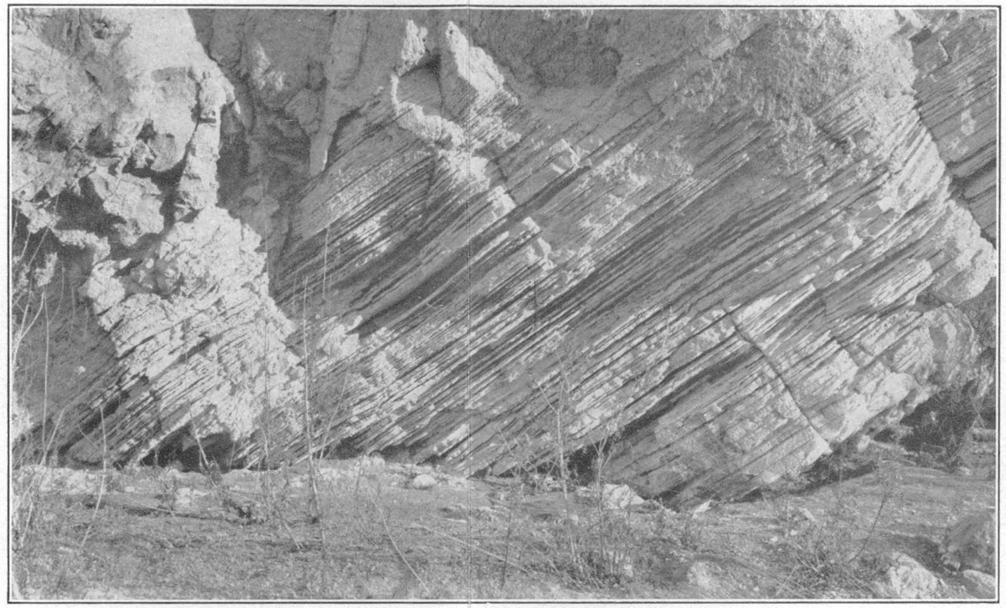


GENERALIZED COLUMNAR SECTIONS SHOWING VARIATION IN CHARACTER AND THICKNESS OF MAGNESITE AND ASSOCIATED BEDS NEAR OVERTON, NEV.



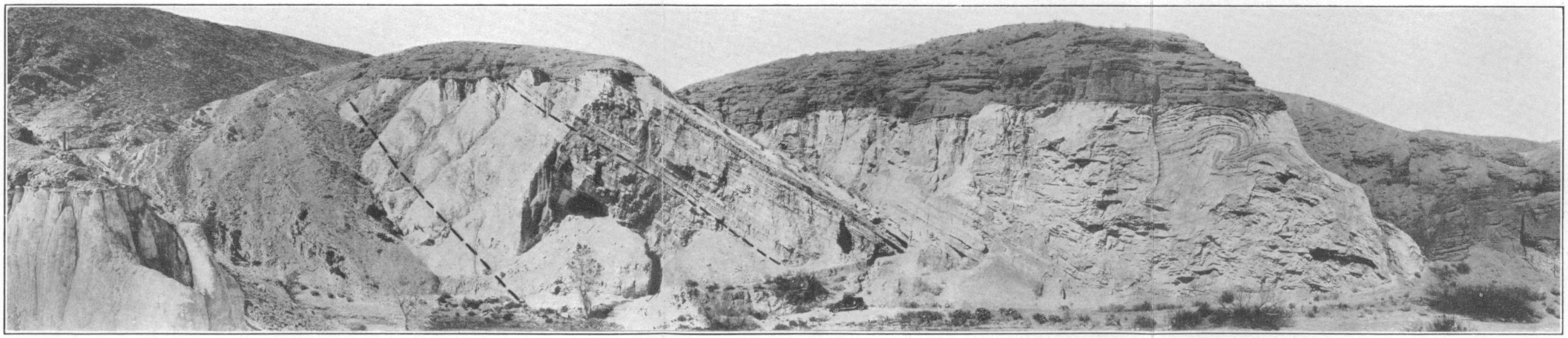
A. VIEW NORTH ACROSS EXPOSURE OF WHITE CARBONATE BEDS (DOLOMITE) WITH ASSOCIATED SILTSTONES, TUFFS, AND CONGLOMERATE, OVERTON WASH.

A partly dissected upland surface on conglomerate of Muddy Creek formation and later gravel slopes northeastward from the dip slope of Overton fanglomerate at left.



B. THIN-BEDDED DOLOMITE 8.6 FEET THICK, SOUTH BANK OF KAOLIN WASH.

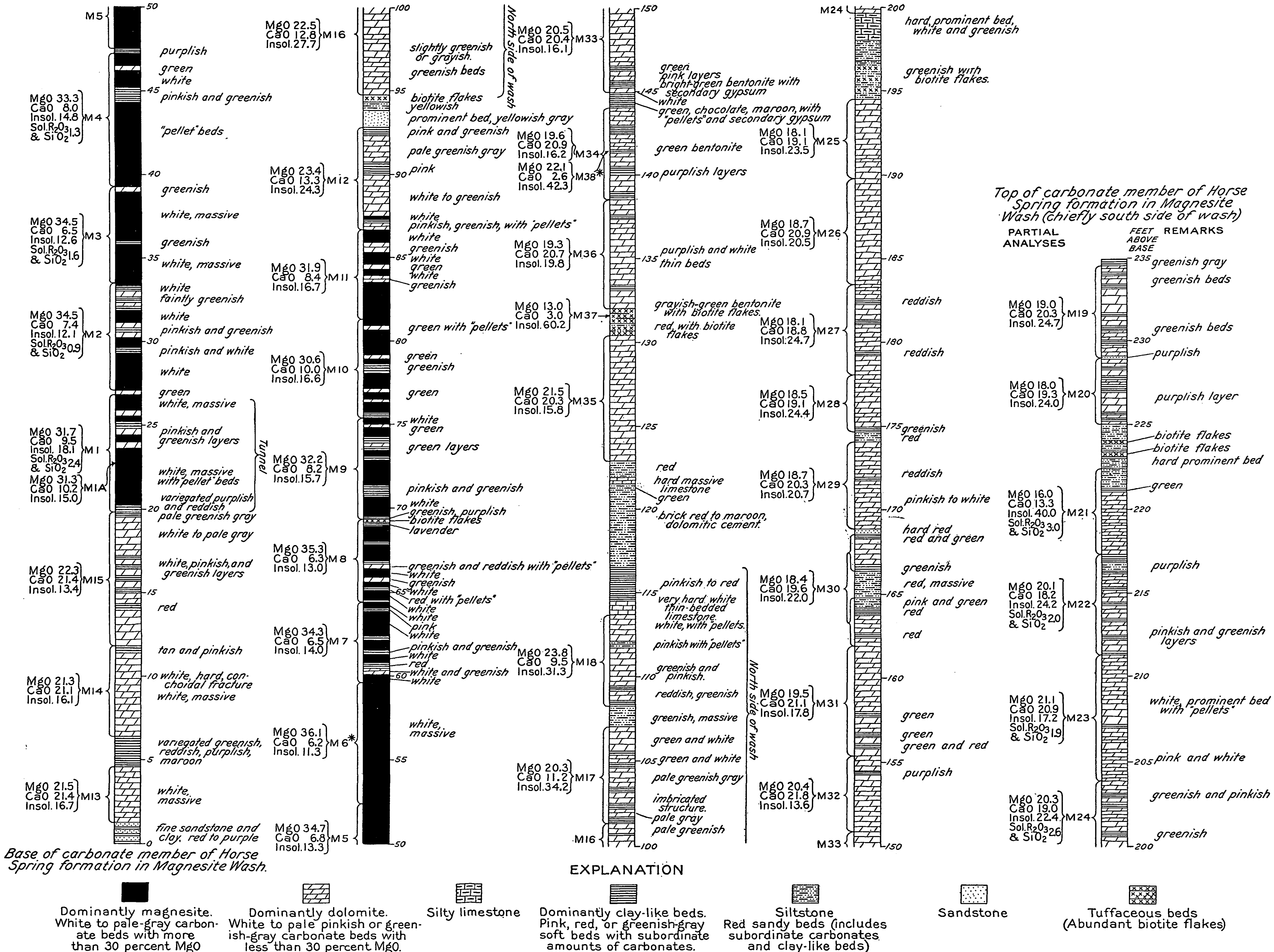
This alternation of dolomitic and claylike beds is particularly common in the upper part of the carbonate unit. (See analyses 28B and 28C.)



C. NORTH BANK OF MAGNESITE WASH.

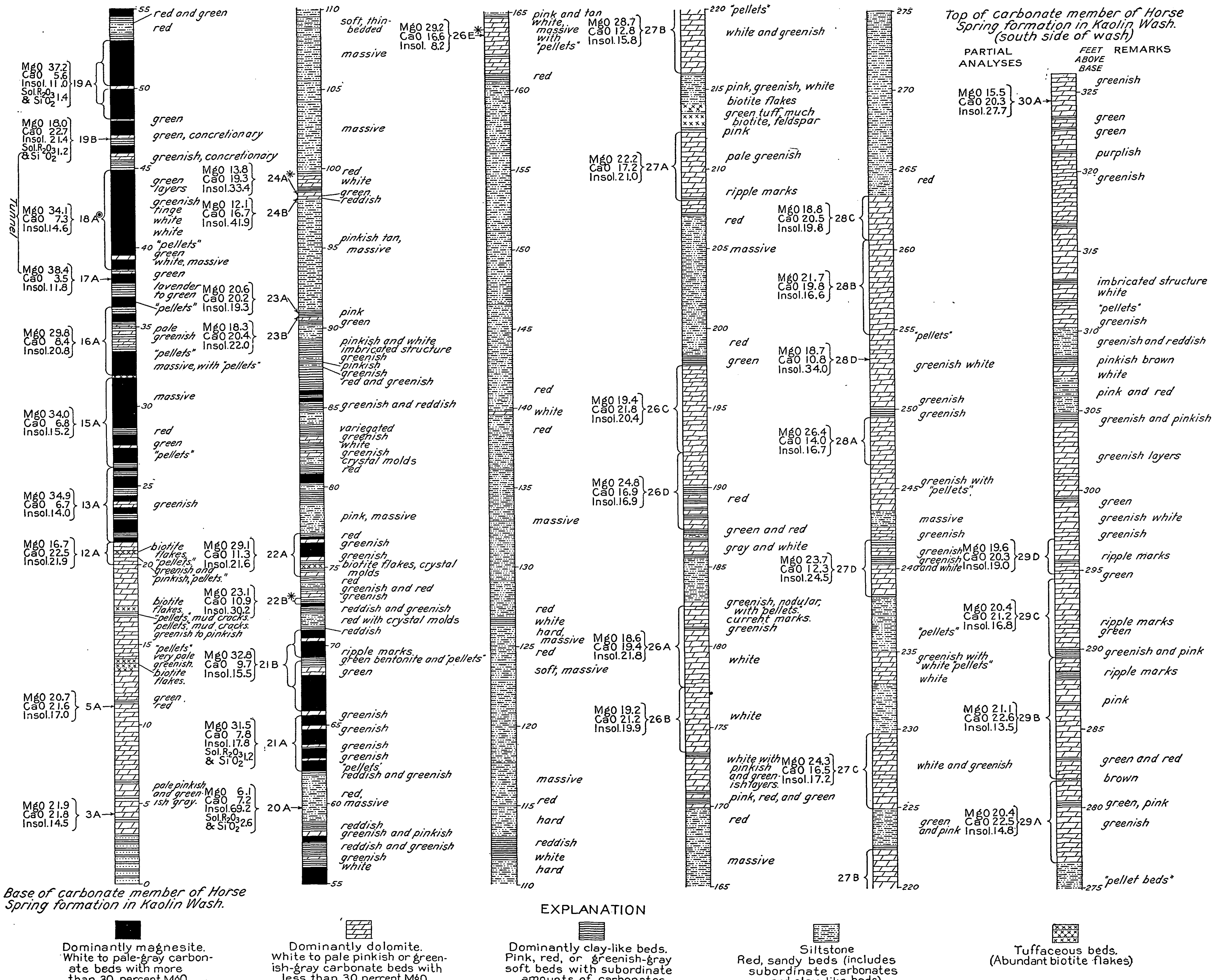
White carbonate beds with ridge of Overton fanglomerate at extreme left. Yellow siltstone unit (dark) underlying the carbonate beds, and conglomerates of Muddy Creek formation unconformably overlying the carbonate beds and faulted against them, at the extreme right. The most highly magnesitic portion, about 65 feet thick, is outlined by the dashed lines.

EXPOSURES OF MAGNESITE AND ASSOCIATED ROCKS NEAR OVERTON, NEV.



DETAILED STRATIGRAPHIC SECTIONS SHOWING CHARACTER AND COMPOSITION OF CARBONATE ROCKS IN MAGNESITE WASH, NEAR OVERTON, NEV.

Partial chemical analyses by R. K. Bailey, E. T. Erickson, J. G. Fairchild, Charles Milton, George Steiger, and R. C. Wells.



* For complete analysis see Table 1.

⊙ For composition of different layers represented in sample 18 A, see Table 2.

DETAILED STRATIGRAPHIC SECTIONS SHOWING CHARACTER AND COMPOSITION OF CARBONATE ROCKS IN KAOLIN WASH, NEAR OVERTON, NEV.

Partial chemical analyses by R. K. Bailey, E. T. Erickson, J. G. Fairchild, Charles Milton, George Steiger, and R. C. Wells.

oratory of the United States Geological Survey by R. K. Bailey, E. T. Erickson, J. G. Fairchild, Charles Milton, George Steiger, and R. C. Wells. Each sample was analyzed for MgO, CaO, and the portion insoluble in dilute HCl. From the 107 partial analyses 7 samples were carefully chosen to represent averages and extremes of chemical composition, and the samples so chosen were then analyzed more completely. Analyses of these 7 samples and of 3 other carbonate rocks from the Horse Spring formation in the same general region, are given in the following table:

43938—36——9

TABLE 1.—*Chemical composition of magnesite, dolomite, and associated rocks in Horse Spring formation near Overton, Nev., and nearby areas*

	B4	ST	M6	22B	100A	CW	24A	26E	M38	105A
Insoluble in ¼ HCl:	6.2	11.54	11.33	30.22	13.14	11.49	33.42	8.22	42.32	[3] 78.63
SiO_2		11.19	11.10			11.23				57.36
Al_2O_3		.10	(1)			.08				12.71
Fe_2O_3		.10	(1)			.05				.11
MgO		.07	(1)			.02				.43
CaO		.08	(1)			.11				.79
TiO_2		None	-----			-----				.40
K_2O		-----	-----			-----				3.71
Na_2O		-----	-----			-----				3.12
Soluble in ¼ HCl:										
SiO_2	.7	.46	[2] .34			.96			.80	.36
Al_2O_3		1.08	1.48			.30			3.31	4.47
Fe_2O_3		.15	.28			.04			.79	1.29
MgO	41.3	37.59	36.14	23.09	21.69	20.28	13.77	29.15	22.13	2.67
CaO	3.1	4.79	6.24	10.89	23.03	24.04	19.32	16.55	2.60	1.11
H_2O-	1.0	2.15	1.95	4.15	2.62	3.55	1.10	1.01	13.23	4.90
H_2O+	2.6	1.82	2.17	4.46	2.62	2.24	.90	1.11	10.09	4.95
CO_2	44.7	40.09	38.96	23.77	35.29	32.47	29.99	42.35	3.61	.56
SO_3		.12	.21			3.26				Trace
P_2O_5										.06
TiO_2		.01	.06			.01				
B_2O_3		None				.18				
FeO			.31							.87
MnO			Trace							
K_2O		.32	.63			.29				
Na_2O		.31	.77			.28				
Li_2O		.22				.17				
Total	99.6	100.65	100.64	96.58	98.39	99.56	98.50	98.39	98.88	99.87

[1] Included with soluble portion.
[2] 0.34 percent soluble in 5 percent Na_2CO_3. After gelatinization in HCl, 8.37 percent SiO_2 soluble in 5 percent Na_2CO_3.
[3] 79.02 percent insoluble, direct determination.

B4, ST, M6, magnesite, with hydrous magnesian silicate and dolomite; 22B, dolomite and hydrous magnesian silicate, with magnesite and clastic silt; 100A, dolomite, with hydrous magnesian silicate; CW, dolomite, with hydrous magnesian silicate and gypsum; 24A, dolomite, with clastic silt; 26E, "pellets" of magnesite in dolomite; dolomite, with magnesite and hydrous magnesian silicate; M38, green clay, hydrous magnesian silicate, with dolomite; 105A, tuff.

B4: Lump sample to represent hard white bed, 0.4 foot thick, at portal of southern of 2 tunnels, Bauer magnesite claim, 17 miles southeast of St. Thomas, Nev. Charles Milton, analyst.

ST: Sample, probably from tunnel on south side of Kaolin Wash, sent to U. S. Geological Survey before present investigation was undertaken. Charles Milton, analyst.

M6: Channel sample to represent 7.2 feet of white massive carbonate on south side of Magnesite Wash. (See pl. 10.) R. C. Wells, analyst.

22B: Lump sample to represent 0.3 foot of "clay" on south side of Kaolin Wash. (See pl. 11.) E. T. Erickson, analyst.

100A: Lump sample to represent white carbonate rock along road on north side of Kaolin Wash. Same as base of 29C on south side of wash. (See pl. 11.) E. T. Erickson, analyst.

CW: Sample (collected by D. F. Hewett) of white carbonate rock associated with colemanite bed at West End Chemical Co.'s mine, south of Muddy Mountains. Charles Milton, analyst.

24A: Lump sample to represent thin green layer associated with carbonates and siltstone on south side of Kaolin Wash. (See pl. 11.) J. G. Fairchild, analyst.

26E: Lump sample to represent 2.2 feet of massive white carbonate rock with greenish and pinkish tints and some "pellet" layers on south side of Kaolin wash. (See pl. 11.) J. G. Fairchild, analyst.

M38: Lump sample to represent thin green clay associated with carbonate beds on south side of Magnesite Wash. (See pl. 10.) E. T. Erickson, analyst.

105A: Lump sample to represent 3.2 feet of white tuff near middle of red siltstone member of Horse Spring formation in Kaolin Wash. (See pl. 8.) Charles Milton, analyst.

The chemical analyses appear to warrant the following conclusions about the representativeness and the reliability of the samples: (*a*) The composition of any one thin bed is almost uniform for at least 70 feet back underground from the outcrop (table 3), and presumably it is almost uniform for at least several hundred feet along the outcrop; (*b*) the successive thin layers which together make up a thick bed show a wide range in composition, but a channel sample adequately represents the average composition of a thick bed that is made up of many thin layers of diverse composition (table 2).

If the samples are accepted as sufficiently representative, the chemical analyses then show that in Kaolin Wash, at the south; in Overton Wash, 2¼ miles to the north-northwest; and in Magnesite Wash, halfway between, the white carbonate rock consists chiefly of clayey dolomite (with an average composition near MgO 20 percent, CaO 20 percent, "insoluble" 20 percent). But in Kaolin and Magnesite Washes (the two southern ones) there is in addition about 50 to 65 feet of rather impure magnesite which contains 30 to 40 percent of MgO. (See pl. 7.)

In Magnesite Wash the rock that averages 30 percent or more of MgO makes a continuous sequence of beds 67 feet thick, the base of which is 20 feet above the base of the carbonate member. In Kaolin Wash the rock that averages 30 percent or more of MgO makes a similar sequence, 48 feet thick, the base of which is 21 feet above the base of the carbonate member. In both washes the layers with the highest content of MgO were found near the middle of this more magnesitic portion of the carbonate member. No trace of these magnesite beds was found in Overton Wash.

TABLE 2.—*Variations in composition of different layers in west wall of tunnel on south side of Kaolin Wash*

[Sample 18A represents entire bed; the other samples represent the constituent thin layers]

Sample	Description	Thickness (feet)	MgO	CaO	Insoluble	Soluble R_2O_3 and SiO_2	Analyst
	ENTIRE BED						
18A	White or pale gray to greenish magnesite; massive to thin-bedded; with pellets and a green layer near base.	6.3	34.1	7.3	14.6		J. G. Fairchild.
	SUBDIVISIONS						
18F	Thinly laminated, granular, with greenish layers.	1.3	34.2	8.9	12.7		E. T. Erickson.
18G	Soft, hackly fracture, greenish tinge.	1.9	32.3	8.1	17.8		Do.
18B	Hard, white, massive	.5	37.7	5.1	10.5		J. G. Fairchild.
18H	Hard, white	1.2	38.5	4.5	11.5		E. T. Erickson.
18I	Pellets in carbonate matrix	.4	32.5	9.6	14.4	1.2	Charles Milton.
Not sampled.	Pale gray	.1					
18K	Green bed with pellets	.2	19.5	13.4	30.6	1.6	Do.
18J	Pale gray, massive	.7	34.9	4.7	17.1	1.7	Do.

TABLE 3.—*Composition of individual thin beds at outcrop and in tunnels, Kaolin and Magnesite Washes*

	18B	18E	18C	18D	101C	101A	102C	102A	M1A	M1B	M103B	M103C
MgO	37.7	38.6	38.9	38.6	36.1	37.6	37.2	35.6	31.3	30.4	37.3	37.6
CaO	5.1	4.3	3.1	3.6	7.0	5.5	4.5	5.7	10.2	11.3	5.9	6.3
Insoluble	10.5	11.0	11.3	11.3	11.2	12.1	11.6	13.2	15.0	14.2	9.4	9.1
Soluble R_2O_3 and SiO_2			1.8		1.9		1.1					1.4

Samples of bed 0.5 foot thick in tunnel on south side of Kaolin Wash:
18B. At portal (near middle of channel sample 18A, pl. 11 and table 2). J. G. Fairchild, analyst.
18E. In tunnel, 23 feet from portal. E. T. Erickson, analyst.
18C. In tunnel, 40 feet from portal. Charles Milton, analyst.
18D. In tunnel, 70 feet from portal. E. T. Erickson, analyst.
Samples of bed 0.5 foot thick in eastern of two tunnels on north side of Kaolin Wash:
101C. At portal. Charles Milton, analyst.
101A. In tunnel, 10 feet from portal (part of channel sample 101B, table 4). E. T. Erickson, analyst.
Samples of bed 0.5 foot thick in western of two tunnels on north side of Kaolin Wash:
102C. At portal. Charles Milton, analyst.
102A. In tunnel, 10 feet from portal (part of channel sample 102B, table 4). R. C. Wells, analyst.
Samples of thin bed in tunnel on south side of Magnesite Wash:
M1A. At portal (2.6 feet above base of channel sample M1, pl. 10). J. G. Fairchild, analyst.
M1B. In tunnel, 17 feet from portal. J. G. Fairchild, analyst.
Samples of thin bed in eastern of two tunnels on north side of Magnesite Wash:
M103B. At portal (1.4 feet below top of channel sample M103A, table 4). J. G. Fairchild, analyst.
M103C. In tunnel, 15 feet from portal. Charles Milton, analyst.

TABLE 4.—*Partial analyses of other samples collected in Kaolin, Magnesite, and Overton Washes*

[J. G. Fairchild, analyst]

	101B	102B	104A	M103A	M104	M105	01	02	03	04	05	06
MgO	33.0	33.1	8.1	32.0	23.5	20.5	18.4	19.8	18.5	20.9	17.0	16.2
CaO	7.4	7.6	14.1	11.1	21.0	20.3	18.8	19.1	17.7	23.1	17.8	17.6
Insoluble	15.6	14.6	52.6	11.0	12.8	19.8	25.4	22.4	28.8	13.9	30.7	32.2

101B. Channel sample to represent 6.25 feet of beds in eastern of two tunnels on north side of Kaolin Wash. Same as samples 21B and upper part of 21A on south side of wash (pl. 11).
102B. Channel sample to represent 4.3 feet of beds in western of two tunnels on north side of Kaolin Wash. Same as upper three-fourths of sample 15A on south side of wash (pl. 11).
104A. Lump sample to represent carbonate-bearing bed 28 feet below top of yellow siltstone member of Horse Spring formation in Kaolin Wash (pl. 8).
M103A. Channel sample to represent 5.7 feet of beds in eastern of two tunnels on north side of Magnesite Wash. Probably about same as sample M6 on south side of wash (pl. 10).
M104. Lump sample to represent contorted dolomite beds in upper part of carbonate member on north side of Magnesite Wash. Probably about same as sample M31 on south side of wash (pl. 10).
M105. Lump sample to represent contorted dolomite beds in upper part of carbonate member on north side of Magnesite Wash. Probably about same as sample M25 on south side of wash (pl. 10).
01. Channel sample to represent 7.4 feet of contorted dolomite beds in upper part of carbonate member, tunnel on south side of Overton Wash.
02. Channel sample to represent 8.5 feet of beds in lower part of carbonate member, western of two shallow cuts 200 feet up southern tributary of Overton Wash.
03. Channel sample to represent 4.4 feet of beds in lower part of carbonate member, eastern of two shallow cuts 200 feet up southern tributary of Overton Wash.
04. Lump sample to represent contorted beds in middle part of carbonate member, tunnel 350 feet up southern tributary of Overton Wash.
05. Channel sample to represent 5.9 feet of contorted beds in middle part of carbonate member, tunnel 400 feet up southern tributary of Overton Wash.
06. Channel sample to represent 4.2 feet of contorted beds in middle part of carbonate member, tunnel on north side of Overton Wash.

This similarity in stratigraphic position of the more magnesitic beds in Kaolin and Magnesite Washes accords well with other details of lithologic character which appear to show that individual beds persist from one wash to another. In fact, the principal difference in the carbonate member in these two washes seems to be the northward thinning of interlaminated red siltstones from 115 feet in Kaolin Wash to about 25 feet in Magnesite Wash. (See pls. 8, 10, 11.)

Detailed correlations of individual beds northward from Magnesite Wash is made difficult by the extreme contortion of the beds in Overton Wash. However, the carbonate member there appears similar to that in Magnesite Wash except that the beds of red siltstone are thinner and the magnesite is absent. Extension of correlations still farther north is even more difficult. The carbonate member may grade northward into the beds of calcite limestone that overlie conglomerate in Tokio and Wieber Washes,[76] or, to judge by the rate of northward thinning of the fine-grained units below the conglomerate member of the Horse Spring (pl. 8), the carbonate beds may grade into or be cut out by this conglomerate about 1½ miles north of Overton Wash, and the limestone to the north may thus be much younger than the magnesite.

The progressive changes in thickness and lithologic character of the different units of the Horse Spring and Overton formations northward along the outcrop from Kaolin Wash to and beyond Overton Wash seem to show that the present strike of the tilted beds is distinctly oblique to the original lines of equal thickness, uniform lithologic character, and similar conditions of deposition. This interpretation is also suggested by the orientation of oscillation ripple marks that are found at several horizons in the carbonate member in Kaolin Wash. These ripple marks, tilted back into a horizontal plane, trend nearly due north, at an angle of about 30° to the present strike of the rocks. On the basis of this scanty evidence, the prediction might be hazarded that the more highly magnesitic beds continue northward obliquely down the dip from Magnesite and Kaolin Washes and that they may possibly be found at considerable depths underground east of the outcrops in Overton Wash.

Mineralogy of the deposits.—The magnesite and associated carbonate rocks of the Overton area are extremely fine-grained, and it is therefore difficult to determine their exact mineralogic character. Under the microscope samples of the purer magnesite are seen to consist largely of a very fine-grained, even-textured carbonate groundmass and a small percentage, at most, of larger crystals and grains of carbonate, quartz, sodic plagioclase, orthoclase, and biotite. These larger grains are angular and commonly about 0.05 to 0.10 millimeters in diameter. At least some of the larger carbonate crystals are dolomite, and some of the larger grains of quartz and orthoclase show various stages of alteration to a carbonate that may be dolomite. The fine-grained groundmass of these samples appears to consist almost entirely of a highly birefringent carbonate in equidimensional grains about 1 to 2 microns in diameter. However, the high birefringence of the carbonate probably tends to mask the presence of other constituents, for even in some of these purer mag-

[76] Longwell, C. R., op. cit., p. 83.

nesites claylike minerals are present in sufficient quantity and are so uniformly oriented that thin sections show an aggregate optical orientation with the gypsum plate. Several efforts to determine the true refractive index of the carbonate in the groundmass were unsuccessful. The individual grains are so small that only a mean index of the fine material (near 1.57) could be found.

Samples known from analyses to correspond more closely to dolomite are similar to the magnesite samples, except that the groundmass is somewhat coarser-grained and the larger clastic grains are more abundant. In two of these dolomitic samples the clastic grains are concentrated along bedding planes from 3 to 4 millimeters apart. However, in another conspicuously thin-bedded sample, the pairs of thin laminae are marked almost entirely by alternations in grain size, the thicker layers consisting of carbonate and claylike particles from 1 to 3 microns in diameter and the thinner layers consisting of carbonate and claylike minerals (with some quartz) in grains from 5 to 25 microns in diameter. The proportion of claylike minerals mixed with the carbonate appears to be about the same in both coarse and fine layers.

Three thin sections of "pellet" beds (small pebbles of carbonate in a carbonate matrix) show abundant subangular fragments of very fine-grained carbonate (magnesite?) from 0.1 to 10 millimeters in diameter, set in a matrix composed of somewhat coarser-grained carbonate and grains of quartz and feldspar. Fragments of clay were noted, and also a very few grains of volcanic glass that show alteration to fine-grained carbonate and to a fibrous or platy claylike mineral.

The siltstones associated with the carbonates contain much larger proportions of clastic quartz grains (the larger ones distinctly rounded) and subordinate quantities of fine-grained carbonate. Thin green clays, interlaminated with the carbonate beds in Magnesite Wash, consist dominantly of fibrous aggregates composed of a pale yellowish-brown, distinctly birefringent claylike mineral that has a mean refractive index of 1.50. Fine-grained carbonates and angular crystals of quartz, sodic plagioclase, orthoclase, biotite, and iron oxides are also present in subordinate amounts.

A sample of white friable tuff from the red siltstone member in Kaolin Wash (see pl. 8 and table 1) consists of abundant angular crystal fragments, from 0.4 to 1.5 millimeters in diameter, and a finer-grained groundmass of partly devitrified pale yellowish-brown glass and intergrown quartz and feldspar crystals from 0.03 to 0.10 millimeter in diameter. The larger crystals are chiefly orthoclase, quartz, labradorite, and biotite, in proportions that indicate a quartz latite tuff. Subordinate amounts of hornblende, iron oxide, and interstitial carbonate are also present. A conspicuous purplish-gray tuff in the red siltstone member in Overton Wash consists largely of relatively fresh shards of glass, with only a small percentage of crystal fragments, about 0.05 millimeter in diameter, of quartz and some feldspar.

More definite information about the composition of the fine-grained carbonate groundmass is given by the chemical analyses, which show several significant relations in the relative abundance of various constituents. First, the molecular ratio or combining ratio of MgO equals or exceeds that of CaO in virtually all the analyses—that is, most if not all the CaO probably is present as dolomite rather than as calcite, a conclusion that accords with the results of numerous field tests with acid. Second, the total combining ratio of MgO and CaO consistently exceeds that of CO_2—that is, some of the MgO or CaO must occur in compounds other than simple carbonates. Third, this excess of MgO and CaO over CO_2 increases with an increase of water and of "insoluble", thereby suggesting that the excess MgO or CaO may be combined as a hydrous silicate.

Published analyses of the sedimentary magnesite at Bissell, Calif.,[77] show these same relations, and the excess of MgO and CaO over CO_2 in samples from that locality led F. W. Clarke to suggest the possible presence of hydromagnesite ($4MgO.3CO_2.4H_2O$). However, samples from the Overton area do not contain sufficient water to balance the excess MgO in the ratio required for hydromagnesite.

In order to test the suggestion noted above, that the excess MgO may be combined as a silicate, additional chemical tests were made. When samples of the Overton magnesite are digested in dilute hydrochloric acid, a noticeable residue of gel remains undissolved, and upon analysis this residue is found to be almost entirely SiO_2. Determinations of "soluble" SiO_2 before and after digestion of the rock in HCl show that this gelatinous silica does not occur as disseminated colloidal silica in the original rock but is present only after the acid treatment. This appears to prove that the gelatinous silica is produced by the decomposition of a silicate, the base of which remains in solution in the acid.

Computations from the analyses indicate that the decomposable silicate has approximately the composition $2MgO.3SiO_2.2H_2O(+).2H_2O(-)$. These ratios are those of the fibrous mineral parasepiolite, which yields gelatinous silica when treated with acid. Minerals commonly known as "meerschaum" (which includes sepiolite and parasepiolite) have been found associated with magnesite in other regions. From a study of the X-ray patterns, C. S. Ross and P. F. Kerr conclude that the silicate in the Overton magnesite is more closely related to saponite than to the sepiolites. However, published analyses indicate that saponite is a distinctly aluminous

[77] Gale, H. S., Late developments of magnesite deposits in California and Nevada: U. S. Geol. Survey. Bull. 540, pp. 514–515, 1914.

magnesium silicate and therefore, until saponite has been redefined, it seems advisable to follow published data and to compare the Overton silicate tentatively to parasepiolite, a mineral with which it agrees in all its properties except X-ray patterns.

Efforts to separate the silicate from the fine-grained carbonate ground mass have thus far been unsuccessful. Other acids than HCl also decompose the silicate along with the carbonate; and decantation and centrifuging have failed to separate the carbonate from the presumably lighter silicate, perhaps because of flocculation of the small particles.

One other persistent relation shown by the chemical analyses deserves mention. In the group of samples analyzed CaO and "insoluble" tend to increase together, and as they increase MgO decreases. Weighted averages of the percentages of CaO and of "insoluble" for different percentages of MgO are shown below. With lower percentages of MgO the relation is not well marked.

MgO	CaO	Insoluble in ¼ HCl
38.0	5.1	10.6
36.0	6.0	12.2
34.0	7.2	13.8
32.0	8.8	15.5
30.0	10.5	17.4

Interpreted in terms of probable mineral constituents, this relation means that, in samples made up of more than one-third magnesite, the other constituents, dolomite and hydrous magnesian silicate, are present in a fairly constant ratio of about 1 part of dolomite to 1 part of silicate. (See fig. 42.)

A heating curve of one of the samples (fig. 41), determined by P. G. Nutting, affords additional information about the mineral composition of the fine-grained carbonate groundmass; but this information is difficult to interpret satisfactorily. The total loss of weight on heating agrees closely with the total CO_2 and H_2O determined chemically in another portion of the same sample. The large loss of weight between temperatures of 415° and 462° corresponds approximately with the percentage of CO_2 thought to be present in the mineral magnesite, and the smaller loss of weight between 462° and 672° with the percentage of CO_2 in the mineral dolomite. However, the temperature of about 440° at which most of the weight is lost does not agree with that at which pure magnesite decomposes,[78] and the uniform rate of weight loss between 450° and 700° shows no evidence of the presence of pure dolomite, which should decompose at some definite temperature or temperatures.

[78] Wells, R. C., The thermal decomposition of some carbonate minerals: Am. Geophys. Union Trans. 15th Ann. Meeting, pt. 1, pp. 238–239, 1934.

A possible interpretation of the heating curve (fig. 41) in terms of the probable mineral constituents of the sample is as follows:

Temperature (°C.)	Heating curve: Percentage loss of weight observed	Chemical analysis: Percentage loss of weight inferred from mineral composition
Room 30°	0.0	1.9 Water loosely held in hydrous magnesian silicate.
100°	1.1	
415°	1.1	0.1 Water from gypsum.
		2.1 Two molecules of water from hydrous magnesian silicate.
450°±	32.0	30.4 Carbon dioxide from magnesite.
840°	9.0	8.6 Carbon dioxide from dolomite. 0.2 Sulphur trioxide from gypsum.
	43.2 (total).	43.3 (total).

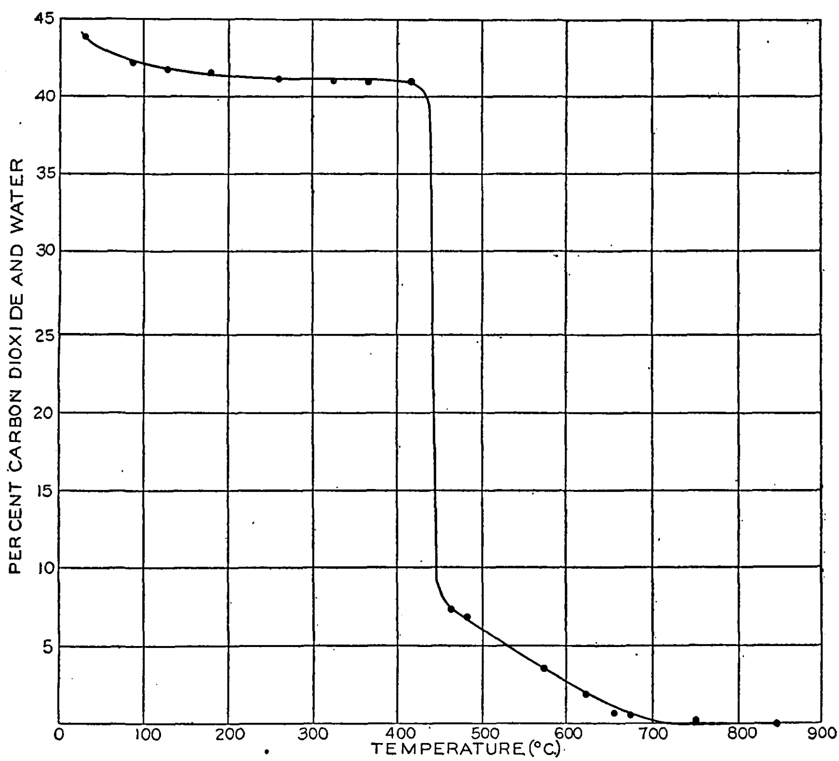


FIGURE 41.—Thermal decomposition and dehydration of magnesite, hydrous magnesian silicate, and dolomite (sample M6) from south side of Magnesite Wash. For location and chemical composition see pl. 10 and table 1. Data by P. G. Nutting.

Further physical data that may bear indirectly on the mineralogy of these carbonate deposits are the following determinations of rock density of samples of magnesite and dolomite from Kaolin Wash. The more magnesitic sample has the higher density. Both determinations are considerably lower than the mineral specific gravity of magnesite or dolomite, but this difference is to be expected because of the porous texture of the rocks.

TABLE 5.—*Rock density of samples of impure magnesite and dolomite from Kaolin Wash, near Overton, Nev.*

[Determined by P. G. Nutting]

Sample (for location see pl. 11)	Rock density at 31° and 65 percent relative humidity (grams per cubic centimeter)	Partial analysis			
		MgO	CaO	Insoluble	Analyst
17A, (magnesite with hydrous magnesian silicate and dolomite).	2.25	38.4	3.5	11.8	J. G. Fairchild.
29C (dolomite with hydrous magnesian silicate)	2.10	20.4	21.2	16.8	George Steiger.

The preceding discussion of the mineral constituents of the fine-grained magnesite and associated rocks of the Overton area may conveniently be summarized in a single composition diagram (fig. 42). Chemical analyses, supplemented by field and microscopic evidence, indicate that the rocks consist dominantly of magnesite, dolomite, and clastic sand, silt, and tuff, with lesser amounts of a hydrous magnesian silicate (parasepiolite?) in many samples. Calcite occurs rarely, and in those samples in which MgO notably exceeds CaO essentially all the insoluble portion appears to be silica from the decomposable silicate—that is to say, in the more magnesitic samples clastic sand, silt, and tuff make up only a small percentage of the rock. It is thus possible to represent all the samples collected as essentially three-component mixtures of dolomite, parasepiolite (?), and either clastic materials or magnesite. Figure 42 shows the results of calculating, into terms of such mixtures, all samples collected in the Overton area and four samples from Bissell, Calif.[79] The general tendency of the plotted points in both fields of the diagram, but especially in the magnesite field, to fall into definite groups and alinements suggests that definite phase-rule relations somehow have controlled the formation of these mineral mixtures.

[79] Gale, H. S., op. cit., p. 514.

Probable origin of the deposits.—The presence of magnesian minerals (magnesite, dolomite, and hydrous magnesian silicate) in such a large mass might suggest that the deposits were formed by a general replacement of earlier rocks by highly magnesian waters; but on close inspection almost no evidence is found to support

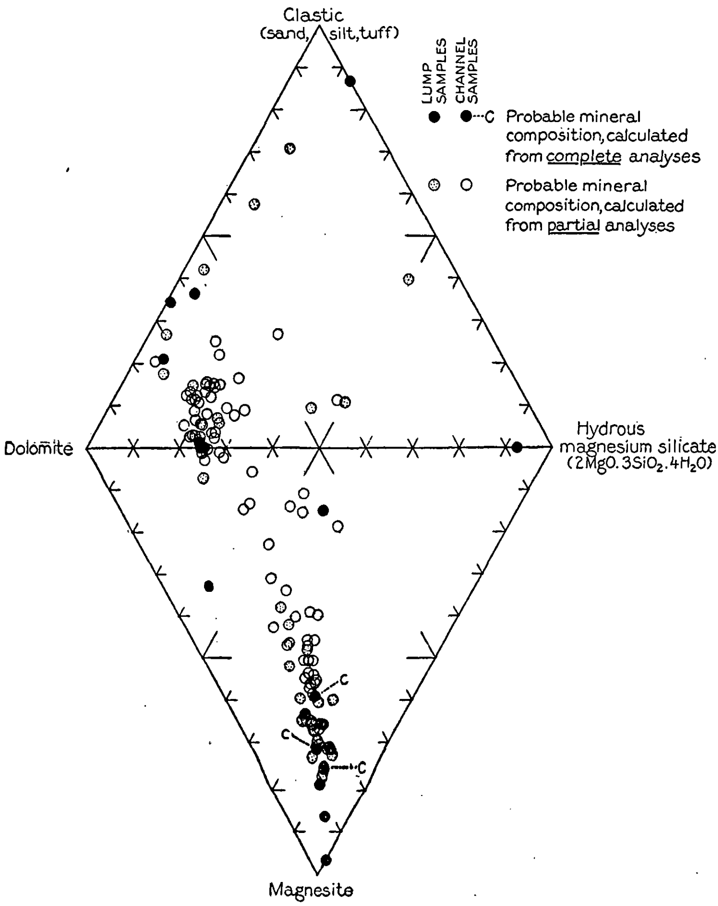


FIGURE 42.—Composition diagram (approximate) of mineral constituents of the magnesite and associated rocks in the Overton area, Nevada.

this view. The exceedingly fine grain of the carbonates, the excellent preservation of all details of depositional bedding, the diverse composition of successive thin beds, and the uniform composition of individual beds traced laterally—all these features of the deposits seem to show that replacement and recrystallization have been negligible, at least since the time of burial.

The thin lamination and lateral continuity of individual beds and the presence of mud cracks, crystal molds, oscillation ripple marks, and "pellet" layers seem to show that these sediments were laid down in a shallow body of standing water; and the presence of beds of coarse fanglomerate below and above the carbonates makes Longwell's suggestion[80] that they were deposited as sediments in a playa lake appear the most reasonable interpretation.

This interpretation seems to carry with it the corollary that the waters of the lake must have been unusually magnesian in composition in order to account for the unusual concentration of magnesian minerals. No positive evidence is at hand to explain this abnormally magnesian character of the ancient lake waters. To judge from the known geology of the region and from rock fragments in fanglomerates of the Horse Spring and Overton formations, the rocks cropping out in nearby mountain masses at the time of deposition were largely limestone and dolomite. This dolomite might possibly have been the source of the magnesium, but if so, conditions must have been such that lime did not reach the lake in quantities sufficient to cause deposition of calcite with the magnesite and dolomite. Pyroclastic rocks are a possible alternative source for the magnesium. Thin beds of tuff are abundant in the red siltstone member of the Horse Spring formation, and tuffaceous beds that carry numerous flakes of biotite recur throughout the carbonate member; but as the tuff examined is of approximately latitic composition, it seems improbable that decomposition of volcanic debris could account for the unusual quantities of magnesium. However, the volcanic debris may have been the source of large quantities of the silica now combined as hydrous magnesium silicate. Longwell[81] suggests that the magnesium may have been brought into the lake by hot springs of deep-seated origin at the time of widespread dolomitization in the area.

If, as it seems necessary to assume, the waters of the ancient lake were for some unknown reason highly magnesian, then the magnesian compounds might be deposited in any one of several ways. Gale[82] has suggested that magnesium sulphate waters, brought into a lake by hot springs, might react with the sodium carbonate waters of the lake to precipitate magnesium carbonate and leave sodium sulphate in solution. An alternative method that also would favor precipitation of magnesium carbonate would be progressive desiccation of highly magnesian lake waters, aided by the escape of carbon dioxide upon warming of the water.

Some experimental work on the solubility of magnesite, dolomite, and parasepiolite (?) was undertaken by P. G. Nutting and R. C. Wells, of the Geological Survey, in order to test the possibility, indicated by the composition diagram (fig. 42), that definite phase relations somehow controlled the formation of these mineral mixtures

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[80] Longwell, C. R., op. cit., pp. 82–85.
[81] Idem, p. 85.
[82] Gale, H. S., op. cit., p. 516.

and also to see if the work might suggest possible commercial processes by which the impurities, lime and silica, could be removed from the magnesia. Fifty grams of lump sample M1B (which contains 30.4 percent of MgO, 11.3 percent of CaO, and 14.2 percent of "insoluble—equivalent to about 38 percent of magnesite, 39 percent of dolomite, and 23 percent of parasepiolite?) was powdered, immersed in distilled water, and held open to the atmosphere at a temperature of 37° to 40° C. for two weeks. The solution was then filtered and evaporated to dryness. The residue was partly crystalline and was made up of artificial (hydrous?) compounds that could not readily be identified with the microscope. Chemical analysis of this residue showed that 17.0 milligrams of MgO, 4.0 milligrams of CaO, and 5.5 milligrams of SiO_2 had been dissolved per liter of water. Second and third extracts from the same powder at the same temperature but for slightly longer and slightly shorter periods contained, respectively, 18.2 and 20.0 mg MgO, 4.3 and 4.4 mg CaO, and 6.8 and 8.3 mg SiO_2 per liter of water. The solubilities thus determined are not strictly accordant, but they are consistent enough to indicate that approximate equilibrium with atmospheric CO_2 had been reached. The most probable solubilities (weighted means) at this temperature are about 19.2 mg MgO, 4.4 mg CaO, and 7.6 mg SiO_2 (equivalent to 26.3 mg magnesite, 14.4 mg dolomite, and 14.1 mg parasepiolite?) per liter of water.

The same powder was then extracted at about 30° C. for 43 days and under these conditions the solubility per liter of water was 21.7 mg MgO, 3.1 mg CaO, and 4.3 mg SiO_2 (equivalent to 36.7 mg magnesite, 10.3 mg dolomite, and 7.9 mg parasepiolite?). Another extract at 84° to 90° C. for 20 hours contained 17.2 mg MgO, 7.0 mg CaO, and 9.2 SiO_2 (equivalent to 16.9 mg magnesite, 23.0 mg dolomite, and 17.1 mg parasepiolite?) per liter of water. In summary, distilled water, approximately in equilibrium with atmospheric CO_2 at three different temperatures, dissolved the three minerals in the following weights and proportions:

Solubility of magnesite, dolomite, and parasepiolite (?) in CO_2-saturated water

	30°		37°–40°		84°–90°	
	Milligrams per liter	Percent	Milligrams per liter	Percent	Milligrams per liter	Percent
Magnesite	36.7	67	26.3	48	16.9	30
Dolomite	10.3	19	14.4	26	23.0	40
Parasepiolite (?)	7.9	14	14.1	26	17.1	30

Magnesite appears to be most soluble at low temperatures, and dolomite and parasepiolite (?) most soluble at high temperatures. The solubilities at these three temperatures fall closely along the alinement conspicuously shown by the composition diagram (fig. 42). This coincidence of field and laboratory data could hardly be fortuitous, and it seems at least to strengthen if not to confirm the proposed interpretation that these minerals accumulated under conditions of low temperature, moderate pressure, and approximate equilibrium with the waters from which they were precipitated.

On the assumption that the laboratory determinations are even approximately indicative of actual solubilities of the three minerals, a possible mode of origin of the Overton deposits may be outlined. Needless to say, the evidence does not preclude alternative interpretations, but one in particular apparently accords with all observations and seems also to account for several otherwise unexplained details of occurrence.

Seasonal variations in temperature of the supposed playa waters would cause marked changes in composition of the chemical sediments. If cool playa waters became approximately saturated with the three minerals and then were warmed without change in volume—that is, without evaporation or dilution—the warmed water would at first be supersaturated with magnesite but undersaturated with dolomite and parasepiolite (?). As a result magnesite would tend to be precipitated, and earlier deposits of dolomite and parasepiolite (?) lying exposed on the lake bed would tend to be dissolved or replaced by magnesite. If however, the warming were accompanied by evaporation and a decided decrease of water volume, the dissolved dolomite and parasepiolite (?) would become somewhat more concentrated and the dissolved magnesite much more concentrated. As a result, small amounts of dolomite and parasepiolite (?) would be precipitated along with much larger quantities of magnesite.

On the other hand, the sequence of events would be different if the water were cooled instead of warmed. If there were no change in volume, the cooled water would tend to precipitate dolomite and parasepiolite (?) and to dissolve or to cause replacement of some of the earlier deposits of magnesite lying on the lake bed. If the cooling were caused not simply by changes in atmospheric temperature but largely by dilution with cold, undersaturated stream waters, the diluted water would then be less concentrated, and re-solution of earlier precipitates, especially of any magnesite that lay exposed on the lake bed, would be hastened. Thus an influx of cold stream waters would leave on the lake bed a thin layer of leached residual dolomite and parasepiolite (?) mixed with whatever sand and silt had been washed into the lake. Frequent or long-continued rainy seasons might result in leaching out all magnesite precipitated during several earlier hot seasons.

With the return of a warmer season, heating and evaporation would again set in, and eventually a new layer of magnesite mixed with subordinate quantities of the other two salts would be precipitated and cover the residual layer. Such an alternation of (*a*) heating and evaporation and (*b*) cooling and dilution would tend to give alternate layers of pure chemical precipitates of the three minerals and leached residues of dolomite and parasepiolite (?) mixed with some clastic sediments. However, the composition and thickness of the alternate layers would depend upon many variable factors—composition and concentration of the added water, intensity and duration of the alternating conditions, and varying area of the playa floor on which the precipitates accumulated. It should be emphasized that of these factors the dominant one—over a period of years—would necessarily be the composition of the incoming water. Waters high in magnesia and low in lime and silica would tend on evaporation to make deposits rich in magnesite, almost regardless of the temperature.

The laboratory determinations of solubility and the proposed explanation of the origin of the deposits have a possible bearing on commercial processes by which the magnesite might be refined. For most purposes of commercial utilization the admixed lime and silica would have to be removed. The Overton deposits are so fine-grained that physical methods of separating the different minerals seem out of the question; and simple chemical processes also appear impracticable because of the ready decomposition of the hydrous magnesium silicate. Any commercial process applicable to these deposits is very likely to be one based upon a much more adequate knowledge than is now possessed of the stability relations of the three minerals.[83] It is hoped that these solubility determinations and conclusions about the probable origin of the deposits may be contributions toward this more adequate knowledge. They suggest that dolomite and parasepiolite (?) behave similarly toward certain solvents and that warm, weak solvents low in dissolved CO_2 would selectively leach these two minerals from much of the Overton material and leave a residue of nearly pure magnesite. However, these experiments and conclusions do not indicate the best solvent nor the most economical process for this purpose.

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[83] For suggestive studies of the stability relations of the carbonates, see Wells, R. C., The solubility of magnesium carbonate in natural waters: Am. Chem. Soc. Jour., vol. 37, pp. 1704–1707, 1915; Johnston, John, The solubility-product constant of calcium and magnesium carbonates: Am. Chem. Soc. Jour., vol. 37, pp. 2001–2020, 1915; Seyler, C. A., and Lloyd, P. V., Studies of the carbonates—part 3, Lithium, calcium, and magnesium carbonates: Chem. Soc. Jour., vol. 111, pp. 994–1001, 1917; Mitchell, A. E., Studies on the dolomite system—part 2: Chem. Soc. Jour., vol. 123, pp. 1887–1904, 1923; Kline, W. D., The solubility of magnesium carbonate (nesquehonite) in water at 25° and pressures of carbon dioxide up to one atmosphere: Am. Chem. Soc. Jour., vol. 51, pp. 2093–2097, 1929; Revelle, Roger, and Fleming, R. H., The solubility-product constant of calcium carbonate in sea water: 5th Pacific Sci. Cong. Proc., vol. 3, pp. 2089–2092, 1933; and especially Bär, Otto, Beitrag zum Thema Dolomitentstehung: Centralbl. Mineralogie, 1932, Abt. A, pp. 46–62.

Estimate of reserves.—The close similarity in composition and thickness of the more magnesitic beds in Kaolin and Magnesite Washes may be taken as proving the continuity of the beds through the 6,000 feet that intervene between these two washes. The magnesite does not reappear with the dolomite in Overton Wash, 1¼ miles to the north. Sporadic outcrops of white carbonate rock between Magnesite and Overton Washes were not sampled, and the exact northern limit of the magnesite is not known. In the absence of more definite information, it is probably conservative to assume that the magnesite is lenslike in form and thins both northward and southward until it disappears about 3,000 feet (half of its proved length) north of Magnesite Wash and south of Kaolin Wash. The volume thus assumed would be equivalent to that indicated by an alternative assumption that the magnesite beds continue with undiminished thickness only one-fourth of the proved length, or 1,500 feet north of Magnesite Wash and 1,500 feet south of Kaolin Wash, and then stop abruptly.

North of Magnesite Wash the dip averages about 34°, between Magnesite and Kaolin Washes about 35°, and south of Kaolin Wash about 42°. Altitudes taken in the washes and on the top and bottom of the gravel deposits in the Muddy Creek formation, which unconformably overlie the magnesite on intervening uplands, indicate that the magnesite extends vertically above the lowest possible tunnel level an average of (*a*) 70 feet (dip length, 125 feet) between Magnesite and Kaolin washes, (*b*) 144 feet (dip length, 257 feet) for 3,000 feet north of Magnesite Wash, and (*c*) 94 feet (dip length, 142 feet) for 3,000 feet south of Kaolin Wash. The overburden of gravel is commonly about 30 to 50 feet thick. On the basis of the determinations of rock density, it is estimated that magnesite containing from 30 to 40 percent of MgO probably averages about 138 pounds to the cubic foot.

From the foregoing data and those on the composition and thickness of individual beds, the following tentative estimates may be made of the total tonnage of magnesite above entry level and virtually in sight. The estimate is made separately for three minimum grades of ore and four minimum thicknesses of minable beds.

Estimated tonnage of magnesite in Overton area

Minimum grade of ore	Magnesite (short tons)			
	In beds 4 feet or more thick	In beds 2 feet or more thick	In beds 1 foot or more thick	In beds 6 inches or more thick
38 percent of MgO	290,000	430,000	760,000	850,000
34 percent of MgO	3,100,000	3,500,000	3,600,000	3,700,000
30 percent of MgO	4,500,000	4,900,000	5,000,000	5,100,000

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BAUER

About 17 miles by road southeast of St. Thomas and 9 miles due north of the former Gold Butte post office, Clark County, Nev., a small area is underlain by beds of fairly high grade mag-

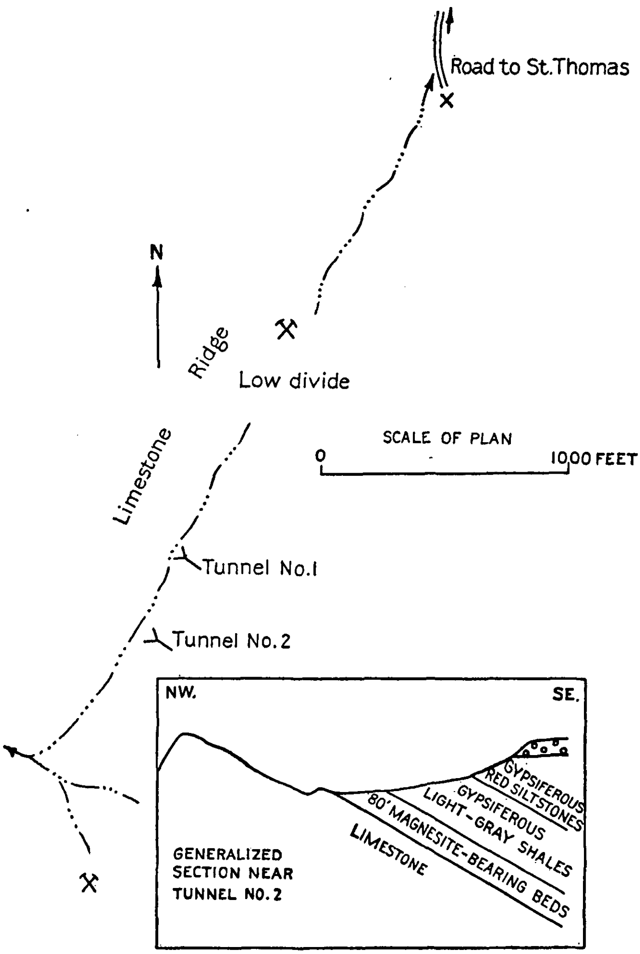


FIGURE 43.—Sketch map of Bauer magnesite deposit, near St. Thomas, Nev.

nesite. Soft white fine-grained dolomite and magnesite, similar to that near Overton, dips 25°–30° ESE. and crops out for a distance of 3,500 feet along the strike. Some exploratory development work has been done, but apparently no material has been shipped, probably because of the relative inaccessibility of the district. (See fig. 43 and pl. 12, *A*.)

Stratigraphic section of rocks exposed on Bauer magnesite claim

	Feet
Muddy Creek gravel	20±
Angular unconformity.	
Horse Spring formation:	
Soft red gypseous siltstone	100+
Light-gray shale and gypsum	170±
Soft white carbonate rock (containing magnesite)	35–80
Hard light-gray limestone, somewhat dolomitic; pitted surface; makes prominent ridge	300±
Red shale and sandstone (base not exposed nearby).	

Thin layers of clay appear to be more numerous in the white carbonate rock here than in the magnesite deposit near Overton.

Four lump samples, taken from the harder rock that contains less clay in the lower 25 feet of the white carbonate unit, were analyzed in the chemical laboratory of the United States Geological Survey by Charles Milton, with the following results:

Partial analyses of samples from Bauer magnesite deposit, near St. Thomas, Nev.

	B2	B3	B4[1]	B5
Insoluble in ¼ HCl	5.7	13.7	6.2	4.0
R_2O_3 and soluble SiO_2	.9	.9	.7	.6
MgO	35.2	20.2	41.3	38.4
CaO	10.3	23.8	3.1	8.5

[1] For complete analysis see table on p. 124.

B2. Hard white bed, 1 foot thick, 15 feet underground from portal of northern of two tunnels. Covered with a copious efflorescence that appears to be bloedite ($Na_2O.MgO.2SO_3.4H_2O$).
B3. Hard white bed, 0.6 foot thick, 2.5 feet below B2.
B4. Hard white bed, 0.4 foot thick, just inside portal of southern of two tunnels.
B5. Hard white bed, 4.5 feet thick, exposed at surface 35 feet north of portal of southern tunnel.

It will be noticed that, although the field description of all samples was the same, B3 is a dolomite, whereas B2, B5, and especially B4 are relatively pure magnesites.

The total thickness of magnesite in this deposit is not known, but if it averages 20 feet, the material above entry level amounts to about 500,000 tons.

NYE COUNTY

Currant.—Bedded magnesite occurs in northeastern Nye County and the adjoining part of White Pine County, in the White Pine Mountains of the Currant district, according to Fulton and Smith. This area was not visited by the writers. The rocks that contain the magnesite extend for several miles along the White Pine Mountains. The magnesite beds are underlain by slate, conglomerate, and tuff and overlain by lava flows. One outcrop of magnesite is 150 feet long, 500 feet wide, and about 20 feet thick, according to Fulton and Smith. The magnesite is white, and some of it is hard and will not break down in water. Analyses made by the Nevada State Mining

Laboratory of samples taken by an engineer of the Nevada State Bureau of Mines are given below (nos. 1, 2, and 3). A sample of magnesite was sent to the writers by P. J. Johnson from a claim in T. 12 S., R. 65 E. The white magnesitic material was analyzed (no. 4 in table below) and found to be rather impure. It contains subangular masses as much as 5.0 millimeters in diameter of an isotropic yellowish-white gel-like substance with a refractive index of 1.517, which, according to the analysis given below (no. 5), is a hydrous magnesium silicate, possibly deweylite. It may be one of the hydrous magnesium silicates present in a finely divided state in the other sedimentary magnesite deposits. Analyses of both materials were made in the laboratory of the United States Geological Survey by Charles Milton. No data on reserves of this district are available.

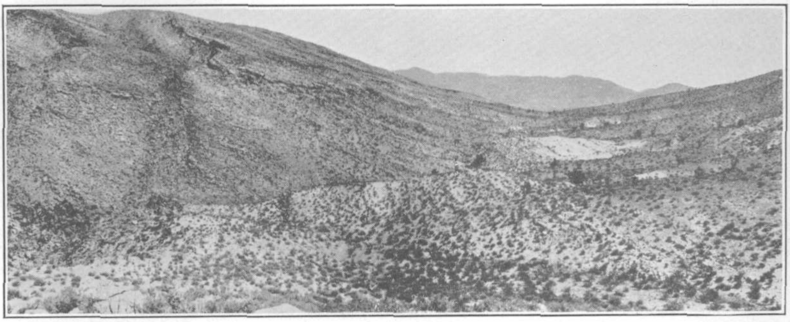
Analyses of magnesite and an associated silicate from Currant district, Nev.[1]

	1	2	3	4	5			
SiO	24.86	14.40	1.50	15.81	SiO_2	40.76	CO_2	0.87
R_2O_3	--------	--------	--------	2.51	Al_2O_3	1.10	TiO_2	.01
MgO	29.00	35.00	42.20	29.53	Fe_2O_3	.37	Na_2O	.05
CaO	7.86	6.80	Trace	15.71	MgO	35.40	K_2O	None
Loss on ignition	--------	--------	--------	36.54	CaO	Trace		
					H_2O-	8.90		99.50
				100.10	H_2O+	12.04		

[1] Fulton, J. A., and Smith, A. M., Nonmetallic minerals in Nevada: Nevada Univ. Bull., vol. 26, no. 7, mimeographed supplement to p. 6, 1932.

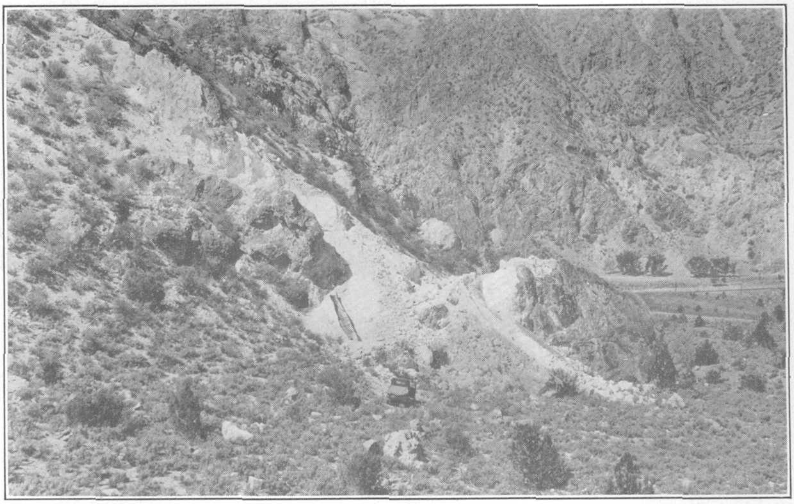
Paradise Range.[84]—Large deposits of brucite ($Mg(OH)_2$) and "crystalline" or marblelike magnesite occur on the west slope of the Paradise Range, Nye County, Nev., 33 miles by road northeast of Luning, a station on the Mina branch of the Southern Pacific Railroad. These deposits have been formed by the alteration of dolomite and are therefore very irregular in shape and distribution, as shown by plate 13. The brucite is mostly covered by a blanket of hydromagnesite averaging between 10 and 15 feet in depth. It has been extensively prospected by the diamond drill to a maximum depth of 405 feet, and numerous chemical analyses of cores have been made by Abbot A. Hanks, Inc., for the owners. Impurities in the brucite consist of dikes and lenses of igneous rock, dolomite as veinlets, masses, and disseminated grains, and silicate minerals. All these can be easily separated except the dolomite. In the better cores MgO ranges between 61 and 65 percent, CaO between 1 and 4 percent, SiO_2 between 0.7 and 4 percent, Al_2O_3 averages about 1 percent, and Fe_2O_3 averages about 0.7 percent. Reserves of brucite to a depth of 350 feet in the upper or eastern deposit are estimated at 3,000,000 tons. A similar estimate for the lower deposit to a depth of 100 feet below the hydromagnesite blanket is 348,000 tons.

[84] Callaghan, Eugene, Brucite deposit, Paradise Range, Nev.—A preliminary report: Nevada Univ. Bull., vol. 27, no. 1, pp. 18–27, 1933.



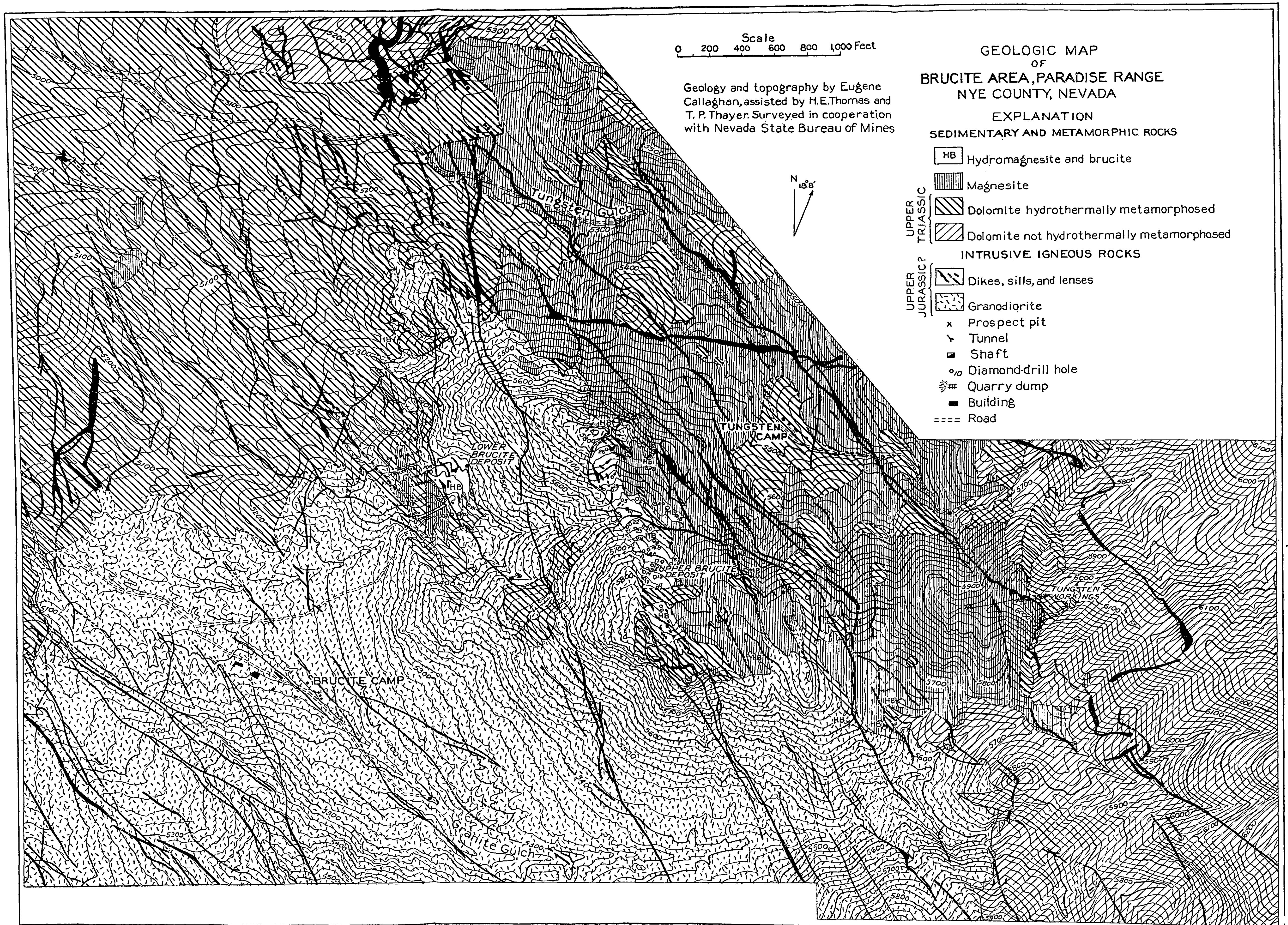
A. BAUER MAGNESITE DEPOSITS NEAR ST. THOMAS, NEV.

Looking north. At left are massive limestone beds of Horse Springs formation dipping to right under light-colored or white beds containing the magnesite. At the extreme right is later gravel.



B. ALUNITE QUARRY ON THE EAST SIDE OF RAINBOW CANYON NEAR BOYD STATION, LINCOLN COUNTY, NEV.

Looking west toward the Union Pacific Railroad tracks at right. Most of the material in view is white altered rhyolite possibly containing a little alunite. The alunite occurs as a lens about 100 feet long and has a maximum width in the outcrop of 8 feet. The automobile in the foreground gives the scale.



GEOLOGIC MAP
OF
BRUCITE AREA, PARADISE RANGE
NYE COUNTY, NEVADA
Scale
0 200 400 600 800 1,000 Feet
Geology and topography by Eugene Callaghan, assisted by H.E. Thomas and T. P. Thayer. Surveyed in cooperation with Nevada State Bureau of Mines
N
18°8'
EXPLANATION
SEDIMENTARY AND METAMORPHIC ROCKS
HB Hydromagnesite and brucite
Magnesite
UPPER TRIASSIC
Dolomite hydrothermally metamorphosed
Dolomite not hydrothermally metamorphosed
INTRUSIVE IGNEOUS ROCKS
UPPER JURASSIC?
Dikes, sills, and lenses
Granodiorite
Prospect pit
Tunnel
Shaft
Diamond-drill hole
Quarry dump
Building
Road
Tungsten Gulch
TUNGSTEN CAMP
LOWER BRUCITE DEPOSIT
UPPER BRUCITE DEPOSIT
TUNGSTEN WORKINGS
BRUCITE CAMP
Granite Gulch

The magnesite body contains much less igneous material than the brucite, though there are numerous dikes in it. Magnesite is very difficult to distinguish in the field from recrystallized dolomite, and the distribution shown on plate 13 is based largely on determinations of more than 300 samples. Probably some dolomite occurs in areas represented as magnesite, and magnesite may have a slightly wider distribution. A total area of magnesite represented on the map is about 136 acres, which to a depth of 100 feet would contain about 55,000,000 tons. This includes, in addition to the large masses, bodies too small to quarry, some igneous rocks, and undoubtedly some dolomite that escaped detection. Depths of 200 or 300 feet for the larger masses are not unreasonable and might very well double the figure given. Probably 40 acres of magnesite occurs outside the mapped area on the mountain north of the tungsten camp. An additional 16,000,000 tons may be available in this area, but no detailed measurements have been made. Partial analyses by Abbot A. Hanks, Inc., of magnesite near the brucite deposits are given below, with one complete analysis (no. 1) by E. T. Erickson, of the United States Geological Survey, of magnesite at the east side of the recrystallized area.

Analyses of magnesite from Paradise Range, Nev.

	1	2	3	4	5	6
SiO_2	0.43	1.81	1.88	3.14	1.38	0.50
Al_2O_3	.13	.62	.73	1.43	.50	.36
Fe_2O_3	.23	.57	.40	.38	.47	.21
MgO	45.35	46.85	39.96	45.78	45.58	45.35
CaO	2.20	1.46	8.87	2.09	1.85	2.55
H_2O-	Negligible	----------	----------	----------	----------	----------
H_2O+	.11	----------	----------	----------	----------	----------
CO_2	51.03	----------	----------	----------	----------	----------
Loss on ignition	----------	48.48	47.86	46.88	49.61	50.53
P_2O_5	.03					
TiO_2	Trace					
FeO	.22					
MnO	.02					
S	.03					
Carbonaceous matter	Trace					
	99.78					

1. Specimen from small body of magnesite in dolomite southeast of tungsten workings at east side of area.
2. Average of 36 feet of core, hole 27, near upper deposit.
3. Average of 7 analyses of upper 127 feet of core, hole 28, near upper deposit.
4. Average of 5 analyses of 68 feet of core below that in no. 2.
5. Average of 12 analyses of 210 feet of core, hole 16, upper deposit.
6. General sample of magnesite in quarry at lower deposit.

OTHER OCCURRENCES IN NEVADA

Gale[85] records reported occurrences of magnesite at Lone Mountain (in Esmeralda County southwest of Tonopah) and at Ash Meadows (in southern Nye County). The report as to the Lone

[85] Gale, H. S., Late developments of magnesite deposits in California and Nevada: U. S. Geol. Survey Bull. 540, p. 520, 1914. See also Fulton, J. A., and Smith, A. M., Nonmetallic minerals in Nevada: Nevada Univ. Bull., vol. 26, no. 7, p. 6, 1932.

Mountain locality has not been confirmed, and an analysis of white fine-grained rock from Ash Meadows proved it to be calcite.

Three reported occurrences of magnesite in the Muddy Mountains area were examined by the writers, and its presence was not confirmed. The white fine-grained carbonate rocks in the Horse Spring formation just west of Horse Spring and 24 miles southeast of St. Thomas were found to be limestone (calcite) rather than magnesite or dolomite. At the West End colemanite mine three kinds of white rock (limestone, dolomite, and tuff) that resemble magnesite were noted. Thin beds of white limestone (calcite) are commonly associated with the colemanite, although one bed (WE7 in table below) was found to be dolomite. Very fine-grained white tuff (WE 1, 2, and 3) occurs above the colemanite bed. North of old Fort Callville white fine-grained carbonate sediments are intimately associated with volcanic breccia. Two lump samples (FC1 and 2) from the most "magnesitic-appearing" beds proved to be dolomite.

Analyses of dolomite and tuff from Muddy Mountains, Nev.

[J. G. Fairchild, analyst]

	WE1	WE2	WE3	WE7	FC1	FC2
Insoluble in ¼ HCl	79.0	87.9	88.5	12.3	21.9	8.9
MgO	1.0	.1	.1	17.4	16.8	20.1
CaO	5.5	1.6	.8	24.4	22.0	26.1

ALUNITE

ARIZONA

YUMA COUNTY

Quartzsite.—Alunite from Sugarloaf Butte, 5 miles west of Quartzsite, has recently been described by Heineman.[86] The alunite occurs in veinlets as much as 1 foot thick in dacite. In a tunnel 200 feet long it appears to form as much as 10 percent of the rock. No figures have been given as to the size of the deposit.

NEVADA

By Eugene Callaghan

CLARK COUNTY

Railroad Pass.—The existence of alunite in the altered rocks of the Railroad Pass district, 6 miles west of Boulder City, has been known for many years.[87] The alunitized area is about 0.8 mile long

[86] Heineman, R. E. S., Sugarloaf Butte alunite: Eng. and Min. Jour., vol. 136, no. 3, pp. 138–139, March 1935.

[87] Hill, R. T., A scientific search for a new gold field: Eng. and Min. Jour., vol. 86, pp. 1157–1160, 1908; Camp Alunite, a new Nevada gold district: Idem, pp. 1203–1206.

in an east-west direction along the highway and about 0.4 mile wide. Some alunite is disseminated through the altered rock, but the most conspicuous part occurs as small, irregular veinlets. In a small tunnel it surrounds fragments of altered rock. In the veinlets it is massive and white, more rarely pink.

According to Gale,[88] the rock would probably not average over 2.5 percent of K_2O, or at most not over 3.5 percent. This would correspond to about 40 percent of alunite. A partial analysis of a sample representing 20 feet of siliceous and alunitic altered rock and veinlets in the eastern part of the area is given below. It indicates about 66 percent of alunite, mainly the potash variety, based on total alkalies and SO_3. Probably large quantities of this impure material could be obtained. (See p. 54.)

Partial chemical analysis of alunite rock from Railroad Pass, Nev.

[R. C. Wells, analyst]

SiO_2	26.05	SO_3	25.17
Al_2O_3	27.77	H_2O-	.38
Fe_2O_3	1.39	H_2O+	9.52
TiO_2	.33		
K_2O	6.58		97.95
Na_2O	.76		

ESMERALDA COUNTY

● *Goldfield.*—According to Ransome,[89] alunite occurs in two ways in the Goldfield district—(1) as small lumps, veinlets, and cavity fillings in the sulphide ores and (2) as a disseminated constituent of altered dacite and rhyolite, which cover several square miles. He does not show that there are any masses of alunite large enough to be mined, nor was the writer able to get any information on such bodies from the local residents. From chemical analyses Ransome calculated that the altered dacite contained about 15 percent of alunite and the altered rhyolite about 10 percent. The principal associated constituents are quartz and kaolinite. From Ransome's map it appears that nearly 6 square miles is underlain by alunitized rock, but it is not known whether all this rock would contain the percentages given above. Obviously many million tons of this low-grade material is available. (See p. 58.)

LINCOLN COUNTY

● *Boyd.*—Alunite occurs in the same group of altered rocks as the clay of the American Clay Co. (see p. 174), and the clay itself con-

[88] Gale, H. S., in Phalen, W. C., Potash salts: U. S. Geol. Survey Mineral Resources, 1915, pt. 2, pp. 111–112, 1917.

[89] Ransome, F. L., The geology and ore deposits of Goldfield, Nev.: U. S. Geol. Survey Prof. Paper 66, pp. 129–133, 176–183, 1909.

tains some alunite as veinlets and irregular masses. A quarry has been opened on a lens of alunite occurring in white altered rock (rhyolite), which probably contains a little alunite. The deposit lies on the east side of Rainbow Canyon near Boyd, 14 miles south of Caliente, less than a mile north of the quarry of the American Clay Co., 0.3 mile east of the tracks of the Union Pacific Railroad and about 200 feet higher. Three carloads of alunite are reported to have been shipped to Los Angeles for fertilizer. The property comprises six unpatented claims.

The general relations of the alunite lens are shown in figure 44, and the nature of the terrane is indicated in plate 12, *B*. The alunite occurs as a nearly vertical lens about 100 feet long, with a maximum width of 8 feet. The alunite is massive, white or pink, and noticeably heavier than the surrounding gray or white porous altered volcanic rock. Obviously only a comparatively few tons of the massive alunite is available, and no other lens of similar proportions has been discovered. Apparently very little alunite occurs in the extensive areas of altered rock surrounding the deposit. A lump sample from the southern part of the lens contained 4.58 percent of K_2O and 15 percent of SO_3 or about 38.5 percent of alunite, according to an analysis by R. K. Bailey in the laboratory of the United States Geological Survey.

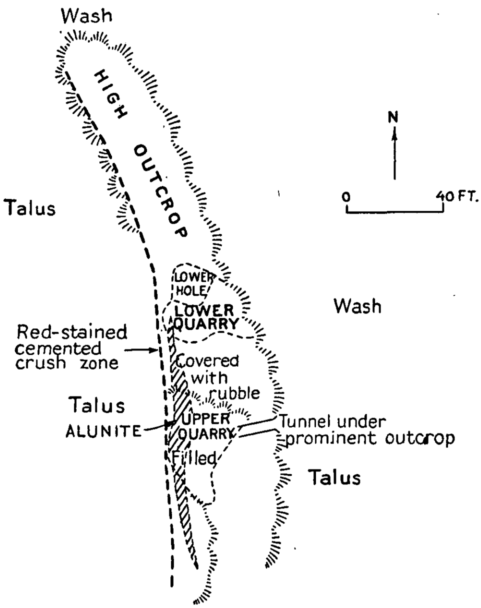


FIGURE 44.—Map of alunite quarry near Boyd, Nev.

UTAH

By D. F. HEWETT

PIUTE COUNTY

Marysvale.—In the high part of the Tushar Mountains, at an altitude of 10,000 feet, about 9 miles by road southwest of Marysvale, several veins of nearly pure alunite have been extensively explored and the product treated to recover potash. One vein with several spur veins has been explored by a tunnel 1,800 feet long, and for 1,000 feet the average width is about 12 feet. Other veins nearby have been slightly explored. About 250,000 tons of alunite containing 10 percent of potash was mined and treated during the World War. The residue, of which 45,000 tons remains on the dump, is high-grade alumina from which metallic aluminum may be recovered. The known reserves of the area approximate 3,000,000 tons of alunite, which contains 1,000,000 tons of crude alumina.

REFERENCES

Butler, B. S., and Gale, H. S., Alunite, a newly discovered deposit near Marysvale, Utah: U. S. Geol. Survey Bull. 511, pp. 64, 1912.

Loughlin, G. F., Recent alunite development near Marysvale and Beaver, Utah: U. S. Geol. Survey Bull. 620, pp. 237–270, 1916.

Thoenen, J. R., Economics of potash recovery from wyomingite and alunite: U. S. Bur. Mines Rept. Inv. 3190, pp. 22–27, 1932.

ALUM

By B. N. Moore

NEVADA

CLARK COUNTY

●*Boulder City.*—Several areas, scarcely 100 acres in total extent, 1 mile west and 3 miles east of Boulder City show sporadic patches and veins of potash and iron alum in highly altered flows. The reserves are considered to be too small to warrant consideration.

ESMERALDA COUNTY

●*Blair.*—An alum and sulphur deposit in the low hills about 12 miles south of Blair Junction, in sec. 30, T. 1 N., R. 39 E. (unsurveyed), has been known since about 1868. A mill and village were built in 1921 in an attempt to exploit it, but after intermittent operation the enterprise was abandoned, and in 1934 the buildings were in a bad state of disrepair.

The geology of the district has been described by Spurr. The rocks are largely Tertiary rhyolite tuffs penetrated by small volcanic necks of rhyolite. In places these rocks are intensely altered and contain sulphur—in one place both sulphur and alum. A sketch map of the deposit is shown in figure 45. The rhyolite containing the alum is altered to a white powdery rock, whose sheeting strikes north and dips about 40°–50° E. The alum occurs both in the powdery rock and in glassy veins with a marked cross-fiber structure resembling that of gypsum. The veins are as much as 1 foot thick and vary greatly in number. At the place marked "unmined spur" in figure 45 they form perhaps 20 percent of the bulk of the rock, but in the bottom of the pit at the north end they appear to be much less abundant. The sulphur appears to be concentrated chiefly in the center of the deposit.

Around the alum-bearing rock is a less intensely altered white zone, which is followed by a still less altered zone marked by red iron-stained rock. The fresh rhyolite is a light-gray sheeted rock.

Sufficient data are not available to make an estimate of the reserves, and there is no information as to the depth to which the alum-bearing rock extends. The difference in the apparent richness of material in the part marked "unmined spur" and the bottom of the main workings suggests that this deposit, like others of its type, may be shallow.

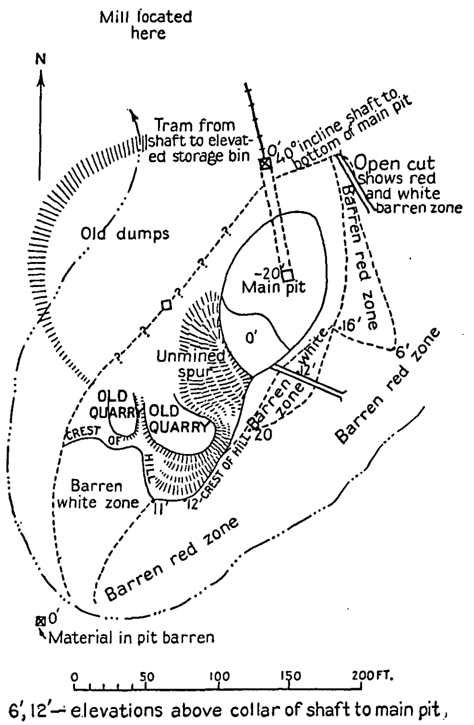


FIGURE 45.—Sketch map of workings of alum mine near Blair Junction, Nev.

SUMMARY

Although alums have been noted at many places in the region, they rarely form even small minable deposits. Although a small production might be made from the deposit near Blair Junction, there is no prospect of sufficient material to furnish the basis for an aluminum or potash industry.

REFERENCES

Spurr, J. E., Ore deposits of the Silver Peak quadrangle, Nev.: U. S. Geol. Survey Prof. Paper 55, pp. 157–158, 1906.

Duncan, L., Recovery of potash alum and sulfur at Tonopah: Chem. Met. Eng., vol. 24, pp. 529–530, March 23, 1921.

SULPHUR

By B. N. Moore

NEVADA

ESMERALDA COUNTY

● *Blair.*—See "Alum."

● *Cuprite.*—Sulphur occurs in a soft white pulverulent tuff near the old station of Cuprite, 12 miles south of Goldfield. It was evidently formed by solfataric action. The sulphur occurs in small sporadic masses, most of which have apparently been removed. (See p. 57.)

UTAH

BEAVER COUNTY

Sulphurdale.—Irregular masses of sulphur and impregnations of sulphur in tuff occur at various places in secs. 17, 19, 20, and 21, T. 25 S., R. 6 W., and sec. 7, T. 26 S., R. 6 W., near Sulphurdale, Utah. The total area of known croppings is about 100 acres. Material from this area has been mined and refined over a period of 50 years yielding a total of about 40,000 tons of sulphur. The reserves are fairly large. The nearest railroad point lies about 20 miles west.

SUMMARY

Sulphur associated with other products of volcanism occurs at many places in this region. A fairly large reserve is found near Sulphurdale, Utah, but under present conditions it does not appear that sulphur can be mined and refined cheaply enough to compete with the sulphur from the Gulf region.

REFERENCES

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Lee, W. T., The Cove Creek sulphur beds, Utah: U. S. Geol. Survey Bull. 315, pp. 485–489, 1907.

BARITE

By B. N. Moore

CALIFORNIA

SAN BERNARDINO COUNTY

● *Barstow.*—Barite occurs as the chief gangue mineral in many of the Tertiary metal veins of the Barstow region but is associated with considerable amounts of iron oxides and other impurities. Large amounts have been mined and shipped for use in preparing heavy drilling muds for California oil fields, but the cost of purification precludes its use for chemical purposes or pigment. (See p. 48.)

● *Calico Mountains.*—In many of the veins in the Calico Mountains barite is present in the gangue. Some production has been made from the Silver Spar property, in sec. 5, T. 9 S., R. 1 E. The vein, which strikes about N. 60° W. and dips about 70° S., is in andesite. At the main shaft it consists of about 3 feet of a massive bladed barite between slickensided walls. The vein may be traced more than 500 feet southeastward on the surface, and the shaft is reported to explore it to a depth of 135 feet. The barite is reported to carry a few ounces of silver to the ton. Another vein striking N. 20° W. crops out west of the main shaft. A mill for grinding and air sorting the barite has been erected on the property, which is about 20 miles by road from Barstow. (See p. 47.)

● *Ludlow*.—The Hansen barite deposit is about 1½ miles northwest of Ludlow, in the southeast tip of the Cady Mountains. Here barite forms veins of varying width striking about N. 45° W. in basalt. About 60 carloads of hematite-bearing barite was shipped for use in preparing heavy drilling muds. (See p. 53.)

TULARE COUNTY

● *Paso Baryta*.—A deposit of barite has been developed on the crest of the drainage divide of the Sierra Nevada, about 15 miles by a steep mountain road from Brown, on the Owenyo branch of the Southern Pacific Railroad. The barite is a white sugary rock that replaces about 5 to 6 feet of a total thickness of 20 feet of thin-bedded limestones that form part of a belt of schist. The strike is N. 20° W., and the dip 70° W. The barite, which contains small amounts of limestone, is explored by 100 feet of tunnel, and the vein crops out for several hundred feet up the mountain side. A minimum of about 10,000 tons is indicated. Offices and bunk houses are located 2½ miles from the mine, in flats beyond the head of Ninemile Canyon.

NEVADA

ESMERALDA COUNTY

● *Lone Mountain region*.—A vein 2 miles long striking nearly east on the west side of Lone Mountain contains considerable barite as a gangue mineral. At one point in sec. 34, T. 1 N., R. 40 E. (unsurveyed), barite has replaced the limestone walls on each side for a thickness of 25 feet, and solution of the limestone by weathering has left chunks of barite 1 or 2 feet across, much of which is pure, coarsely crystalline material. At this point the vein is exposed for about 150 feet. Outside the weathered parts the barite is intimately associated with limestone. In places there is much silica and small amounts of metallic sulphides. The deposit lies about 20 miles from the nearest rail point. A small production was reported in 1916 by the American Barium Co.

NYE COUNTY

● *Ellendale*.—A deposit of massive fine-grained barite has been located in low rolling country about 4 miles east of the old mining camp of Ellendale and 28 miles by road east of Tonopah. The details of the surrounding rocks are hidden by extensive alluvium and sand, but the barite evidently forms a roughly elliptical body in a series of Tertiary tuffs. As shown in figure 46, the eastern edge of the barite is in contact with vertical sheeted or bedded tuffs, but along the western edge it is covered by alluvium. The barite along the contact appears to grade into the tuffs in a distance of a few feet, and both the barite and tuff may be silicified near the contact.

The barite is a very fine-grained rock, mostly very light gray, and considerably fractured. It is slightly iron-stained along surface fractures but is otherwise of good quality.

No information is available as to the depth of the deposit other than that a drill hole was put down 26 feet in barite. If the walls of the deposit remain essentially vertical a reserve of 1,000 short tons is indicated for every foot of depth. (See p. 67.)

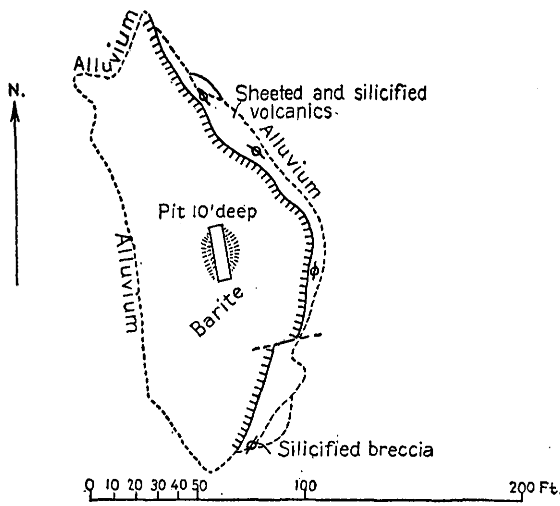

FIGURE 46.—Sketch map of barite deposit near Ellendale, Nev.

SUMMARY

Barite is common in this region, particularly as a gangue mineral in the Tertiary metal veins in some districts. Most of the deposits are relatively small and of poor quality, but with sufficient demand a moderate production might be made.

REFERENCE

California State Mineralogist 27th Ann. Rept., pp. 371–373, 1931.

CELESTITE AND STRONTIANITE

ARIZONA

By B. N. MOORE

MARICOPA COUNTY

● *Aguila.*—A large deposit of celestite (strontium sulphate) occurs in the Vulture Mountains in the NW¼ sec. 20, T. 6 N., R. 7 W., about

15 miles southeast of Aguila on the Atchison, Topeka & Santa Fe Railway. The deposit was discovered and is owned by Milton Ray, of Aguila.

In the vicinity of the deposit the Vulture Mountains are a low rugged range made up of a series of volcanic rocks of both siliceous and basaltic types, several thousand feet thick. The central part of the series, which is dominantly a shaly tuff, contains layers of celestite. Extensive faulting has given an intricate structural pattern to the rocks of the district.

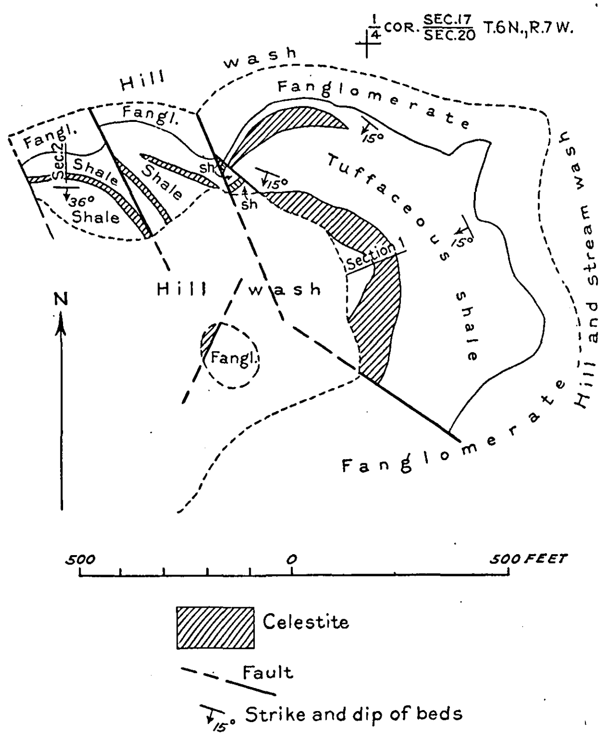

FIGURE 47.—Sketch map of celestite deposit near Aguila, Ariz.

The deposit occurs in a valley on the tip of a northeasterly spur on which may be seen several old terrace levels. Around the base of the spur shown in figure 47 is exposed a dark-purple fanglomerate made up of granitic and volcanic debris. Resting on this is a shaly tuff, which extends upward about 100 feet to a narrow bench formed of resistant beds of celestite rock that weather out as a gray cliff. Above this bench the ground rises steeply to an old terrace level from which material has washed down over most of the hill slopes. More celestite rock is found southwest of the small area shown in the sketch map, but the croppings are mostly hidden by hillside wash. The celestite occurs as beds in the shaly tuff member at several horizons. The following sections show its mode of occurrence:

Sections in celestite zone near Aguila, Maricopa County, Ariz.

NW¼ NE¼ sec. 20, T. 6 N., R. 7 W.

	Feet
Light-brown shaly tuff.	
Interbedded shaly tuff and thin-bedded celestite rock	15.0
Medium-grained buff celestite rock, massively bedded	2.4
Light olive-buff shaly tuff, weathering brown	.2
Massively bedded medium-grained buff celestite rock	.8
Thin-bedded celestite rock and shaly tuff	1.2
Massively bedded medium-grained buff celestite rock	3.5
Thin-bedded celestite and shaly tuff	2.0
Massively bedded medium-grained buff celestite rock	1.2
Olive-buff shaly tuff, weathering brown.	
	26.3

NE¼ NW¼ sec. 20, T. 6 N., R. 7 W.

	Feet
Alluvium with caliche capping.	
Yellowish-green clayey tuffs	60.0
Thin-bedded fine-grained celestite rock; silicified laminae weather out as scabby brown bands	5.5
Shaly tuffs; details obscured by hill wash	11.0
Massively bedded medium-grained buff celestite rock	1.5
Olive-buff shaly tuff	.1
Massively bedded medium-grained buff celestite rock	1.7
Olive-buff shaly tuff	.1
Massively bedded medium-grained buff celestite rock	.4
Olive-buff shaly tuff	.1
Massively bedded medium-grained buff celestite rock	1.2
Shaly tuff with lenses and nodules of celestite rock	.6
Shaly celestite rock	1.3
Massively bedded medium-grained buff celestite rock	1.0
Shaly tuff with nodules of celestite rock	1.0
Massively bedded medium-grained celestite rock	1.6
Shaly tuff	.2
Medium-grained celestite rock	.1
Olive-buff shaly tuff	1.0
Massively bedded medium-grained celestite rock	.5
Olive-buff shaly tuff, weathering brown	3.7
Thin-bedded shaly tuffs hidden by hill wash; lower part contains celestite rock locally but is extensively though irregularly silicified	63.0
Dark red to purple fanglomerate formed of granite and volcanic rock debris.	
	155.6

Surface croppings and pits indicate that the celestite rock lies under an area of about 18,000 square yards. If the total thickness present is assumed to be 9 feet and no allowance is made for the variable dip of the beds, the total amount of celestite rock is about 180,000 short tons. More exists to the southwest of the area shown in figure 47. (For analyses see p. 161.)

Gila Bend.—Celestite occurs about 15 miles south of Gila Bend and about 3 miles east of Black Rock siding on the Tucson, Cornelia & Gila Bend Railroad. The deposits lie on the northwest side of a low range that rises from the plain on which Gila Bend is built. They occur in a series of tuffs from which the pediment of the mountains is carved and upon which rest the basaltic lavas that form the mountains. The deposits are covered at most places by a thin mantle of gravel.

The celestite occurs with gypsum, sandstone, and a conglomerate and strikes in a more or less northerly direction, with steep dips to the east over a distance of 5,000 feet. Only the southern part of the zone was examined. There the celestite occurs in beds that crop out at several places over a distance of 750 feet, strike N. 65° E., and dip 28° SE. The main bed is 2 to 3 feet thick and can be traced the entire distance, but at places there are less continuous beds interlayered with the tuffs, which bring the thickness of the zone up to a maximum of 6 feet.

On the assumption of a length of 750 feet, a thickness of 2 feet, and a distance of 50 feet on the dip, the amount of celestite rock present would be about 9,000 short tons. If, as is probable, the celestite zone extends farther along the strike, this estimate would be greatly increased. (For analyses see p. 161.)

CALIFORNIA

IMPERIAL COUNTY

Fish Mountains.—A deposit of celestite associated with gypsum occurs in the Fish Mountains of the Salton Sink, in sec. 18, T. 13 S., R. 9 E., about 26 miles north of Plaster City and 1 mile east of the gypsum quarries of the Pacific Portland Cement Co. The Tertiary sedimentary section in this district is represented by patches of a very thick gypsum bed, which rests on deeply weathered granitic rocks. The gypsum may be related to the marine Miocene rocks of the Coyote Mountains, to the south. The celestite rock forms a ragged dissected capping of nearly flat-lying beds on an isolated hill of the gypsum. A section measured on the southwest corner of the hill is as follows:

Section in celestite zone of Fish Mountains, Imperial County, Calif.

	Feet
Celestite rock, massive, white	10
Interbedded gypsum and celestite	3
Gypsum; a few nodules of celestite near top	100
Deeply weathered granite.	
	113

The celestite rock is uniformly pure and is free from silicified material. It is not known whether continuations of the bed exist at other places in the district.

The ragged capping on the hill contains more than 10,000 tons of celestite rock. (For analyses see p. 161.)

SAN BERNARDINO COUNTY

● *Argos.*—A celestite deposit lies in the dissected fan heads of the southern slope of the Cady Mountains in secs. 19 and 20, T. 8 N., R. 7 E., about 3 miles northwest of Argos station on the Atchison, Topeka & Santa Fe Railway. The Cady Mountains are a high rugged range formed of a succession of brightly colored volcanic formations including ash and lavas whose structures trend from west

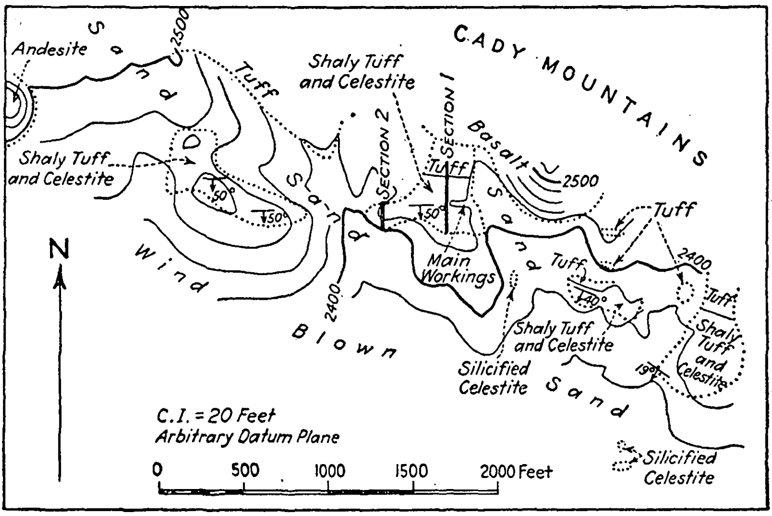

FIGURE 48.—Sketch map of celestite deposit near Argos, Calif. Contour interval 20 feet; arbitrary datum.

to N. 60° W. and are cut by dikes and stocks. Along the southern base of the range a coarse white tuff, part of the volcanic series, is exposed and is overlain by a shaly tuff that contains the celestite rock.

The celestite zone crops out for 4,000 feet along the center of the mountain front, as shown in figure 48, and is dislocated by obscure faults, which are indicated by the displacement of the outcrops. In the eastern part of the area the dips are about 20° S., but in the western part they average 50° S. The celestite occurs in beds as much as 5½ feet thick interbedded with shaly tuff and tuffaceous clay. It is mostly a finely crystalline rock of light-buff and green tints, but some varieties are almost porcelaneous in texture and have a delicate pink tint. Microscopic examination shows that it all contains some chalcedony, which has replaced the celestite. In the eastern part of the district jasper and chalcedony have replaced large bodies of the celestite rock. The mode of occurrence is shown in the following sections:

Sections in celestite zone near Argos, in SE¼ sec. 19, T. 8 N., R. 7 E., San Bernardino County, Calif.

1. Measured from south to north

	Ft.	in.	Ft.	in.
Top of section hidden by dune sand.				
Interbedded fine-grained celestite rock and shaly tuff; celestite rock in beds as much as 4 inches thick, forming one-fourth to one-third of total thickness			61	8
Celestite rock; laminations marked by faint streaks of greenish clayey material along which manganese oxides have been deposited (sample 5, p. 161)	3	5		
Thinly laminated celestite rock with thin clayey partings; manganese stains common (sample 4)	1	6		
Green ocherlike material	1	4		
Red ocher	2	10		
Green ocherous clay	4			
Thin-bedded celestite with thin partings of clayey tuff (sample 3)	1	8		
Green ocherous clay with celestite nodules	1	8		
Thin-bedded celestite rock and clayey tuffs, in part jasperized	1	8		
Thin-bedded celestite rock with partings of shaly tuff; more than three-fourths celestite rock	5	3		
Clayey tuff with celestite nodules, in part silicified and forming about three-fourths of total material (sample 2)	1	9		
Celestite rock, massive, but with faint streaks of clay, suggesting lamination in places (sample 1)	4	6		
			41	9
Covered by alluvium			6	
Croppings of celestite rock			2	
Covered by alluvium			4	
Croppings of celestite rock			2	
Shaly tuffs with numerous red and yellow jasperized beds; details hidden by alluvium			41	
Shaly tuffs; details hidden by alluvium			93+	
			301	10+

Sections in celestite zone near Argos, in SE¼ sec. 19, T. 8 N., R. 7 E., San Bernardino County, Calif.—Continued.

2. Measured from south to north 500 feet west of section 1

	Ft.	in.
Top of section hidden by dune sands.		
Massive celestite characterized by numerous cavities and stained brown from weathering (sample 9)	3	5
Covered by alluvium	13	
Massive sugary celestite rock showing evidence of some recrystallization and streaked pink. Along the weathered pink stripes black manganese oxide occurs (sample 8)		6
Covered by alluvium	15	
Fine-grained massive celestite rock striped pink and light buff and silicified in many places in direction of the stripes (sample 7)	2	3
Covered by alluvium	8	6
Massive celestite rock rendered porous by weathering and marked by numerous red stripes. Manganese oxides form streaks and tiny nodules, and there are many silicified spots in the rock (sample 6)	2	3
Covered by alluvium	3	2
Very fine-grained, almost porcelaneous light-pink celestite rock, containing at base streaks of large sand grains and small pebbles of volcanic rocks. Small masses of manganese oxides the size of a pinhead are common (sample 5)	8	4
Covered by alluvium	1	6
Massive fine-grained celestite rock streaked pink and spottily silicified (sample 4)	1	6
Covered by alluvium	12	6
Fine-grained light olive-green celestite rock showing recrystallization along veinlets (sample 3)	4	6
Thin-bedded celestite rock and shaly tuff	6	
Celestite rock, fine-grained, light olive-green, with a few clayey partings (sample 2)	3	
Celestite marked by thin laminations defined by thin streaks of clayey tuffs and colored pink along laminations (sample 1)	5	6
Green ocherous clay		3
Celestite rock, massive, fine-grained	1	
	81	8

On the assumption that the dimension along the strike is 2,000 feet and that along the dip 50 feet, the total thickness of available celestite rock 50 feet, and its density 3.9, the western part of the deposit would contain altogether about 600,000 tons of celestite of different grades. The amount of celestite in the eastern district that has escaped silicification should be added to this figure, but present work affords no basis for an estimate of the quantity. (For analyses, see p. 161.)

Avawatz Mountains.—The celestite deposits of the Avawatz Mountains have figured extensively in the literature of strontium deposits. They are located on patented claims belonging to the Avawatz Salt & Gypsum Co., of Los Angeles, Calif., on the northeast slope of the Avawatz Mountains 20 to 30 miles by road from Riggs, on the Tonopah & Tidewater Railroad. The deposits occur in a series of Tertiary lake beds that contain extensive beds of gypsum and salt and form a gigantic sliver of rock about 10 miles long crushed between blocks of ancient crystalline rocks. The gypsum occurs through the entire length of the sliver, but the salt is concentrated near the center. The celestite is apparently restricted to two localities near the north end.

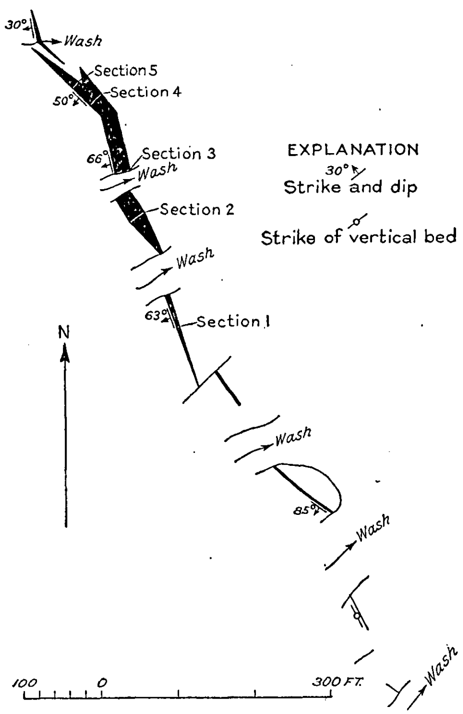

FIGURE 49.—Sketch map of celestite deposit in the Avawatz Mountains, Calif.

The larger of the deposits occurs in the extreme southerly tip of a low range of hills west of the road between Denning Spring and Confidence Mill about 4 miles by road northwest of Denning Spring. The celestite forms a series of thin beds in a zone of gypsum about 20 to 30 feet thick. Croppings may be traced for 1,000 feet, but at each end the beds thin out and are represented by nodules in the gypsum. Figure 49 shows the plan of the beds, and the following sections indicate the manner of occurrence of the celestite:

Sections near center of sec. 24, T. 18 N., R. 5 E., San Bernardino meridian (unsurveyed), Avawatz Mountains, San Bernardino County, Calif.

1. Measured from west to east

	Ft.	*in.*
Gypsum	4	
Massively bedded medium-grained celestite rock	3	3
Green gypsiferous celestite rock		3
Gypsiferous celestite rock	2	2
Greenish gypsiferous clayey celestite rock		3
Massively bedded medium-grained celestite rock	2	2
Manganiferous, gypsiferous celestite rock	1+	
	13+	

Sections near center of sec. 24, T. 18 N., R. 5 E., San Bernardino meridian (unsurveyed), Avawatz Mountains, San Bernardino County, Calif.—Con.

2. Measured from west to east

	Ft.	in.
Gypsiferous celestite rock with manganese stains	3	
Gypsiferous celestite rock with nodular manganiferous masses at base	4	2
Gypsum	6	
Massively bedded medium-grained celestite rock		6
Gypsum with some nodules of medium-grained celestite	2	6
Massively bedded medium-grained celestite rock	2	6
Gypsum	2	
	20	8

3. Measured from west to east

	Ft.	in.
Gypsum.		
Massively bedded medium-grained celestite rock, manganiferous at base	3	6
Massively bedded medium-grained celestite rock	2	6
Manganiferous gypsum	1	6
Massively bedded medium-grained celestite rock, manganiferous	6	4
Massively bedded medium-grained celestite rock	1	7
Interbedded celestite rock and gypsum		6
Gypsum	5	6
Gypsiferous clays.		
	22	5

Composite section measured from west to east

	Ft.	in.
Section 5:		
Manganiferous gypsum, with masses of medium-grained celestite rock near base	4	
Gypsiferous and manganiferous celestite rock	2	
Manganiferous gypsum; contains much celestite in scattered crystals	1	6
Section 4:		
Gypsum with reniform nodules of medium-grained celestite	11	
Nodules of medium-grained celestite, forming bed		6
Gypsum	4	
Massively bedded medium-grained celestite rock		3
Gypsum	4	
Gypsiferous clays.		
	27	3

The second locality is in the easternmost part of the hills just north of the road between Saratoga Springs and Denning Spring. The celestite occurs in lenses and lenticular beds in a series made up of layers of sand, clay, and gypsum which cap an irregular hill about 1,000 feet long and 300 feet wide. The following section was measured on the southeast corner of the hill in beds exposed in a prospect trench in the northeast corner of sec. 27, T. 18 N., R. 5 E. (unsurveyed):

Section in celestite zone of Avawatz Mountains, San Bernardino County, Calif.

	Feet
Thin-bedded gypsum with lenticular beds of celestite as much as 6 inches thick forming one-fourth of total thickness	3
Gypsum with a few celestite lenses	6
Green tuffaceous clay and sandy tuff with lenses of celestite 1 to 16 inches thick and as much as 10 feet long	20
Green clay and sandy tuff.	
	29

In the western body an estimate based on a thickness of 2 feet of celestite rock for a distance of 1,000 feet on the strike and 50 feet on the dip gives 12,000 short tons. If the beds increase or decrease in thickness with depth the estimate will be affected materially. The eastern body is not regarded as having commercial importance. (For analyses, see p. 161.)

Barstow.—Deposits of strontianite (strontium carbonate) occur 10 miles northeast of Barstow in low hills in secs. 29 and 30, T. 11 N., R. 1 W. Patented claims covering the richer parts are owned by L. G. Henderson and T. G. Nicklin, of Barstow. The strontianite occurs as nodular masses and concretions in shaly tuffs and clays, but these are mostly less than 1 cubic yard in size. Small amounts can be obtained by "gophering" after masses in weathered ground near the surface, but such masses are probably not numerous enough to pay for prospecting.

SUMMARY

Analyses of strontium ores from the various deposits have been made with the following results:

Analyses of celestite rock from southeastern California and western Arizona

District	Location	No.	Percent by weight											$SrSO_4$ calculated from SrO
			SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	CO_2	H_2O	SrO	BaO	MnO	
Argos	Section 1, sample 1	1	2.05	0.45	0.15	1.55		40.80	Little	0.50	50.50	0.13	None	89.5
	3	2	2.80	0.55		.75		41.20	Little	.55	51.55	.63	0.005	91.4
	4	3	7.05	1.80		1.65		37.30	Little	1.10	47.75	.26	.02	84.6
	5	4						34.34	None		43.35	.64	Trace	76.8
	6	5						38.33	Trace		48.53	.73	Trace	86.0
	Section 2, sample 1	6	18.02	.66	.05	.96		34.49	0.03		44.35	.09	None	78.5
	2	7						35.85	None		44.39		None	78.6
	3	8						41.41	.70		50.53		None	89.6
	4	9						29.88	Trace		36.16	1.70	Trace	64.1
	5	10						31.52	7.90		39.52	.76	.17	70.0
	6	11						36.89	1.40		45.29	.51	.05	80.3
	7	12	17.86	.98	.38	2.81	0.17	31.49	.27	1.60	40.55	1.19	Trace	72.0
	8	13	2.20	.21	.46	5.34	.08	36.88	4.05	.03	47.73	1.14	.02	84.6
	9	14	1.53	.92	.54	.97	.11	41.08	.30	.56	52.35	1.07	Trace	92.6
Fish Mountains	Representative sample	15	.90	.49	.50	2.47	.05	41.44	.71	.16	52.88	1.53	Trace	93.8
Gila Bend	Main workings	16	5.82	.66	.57	1.89	.23	36.91	2.13	.53	49.97	.98	Trace	88.5
Avawatz Mountains [1]		17				.75		42.38	.92		50.99	Trace		90.4
		18									38.41			68.1
		19									47.92			84.9
Gila Bend [2]		20									49.36			87.5
		21									48.99			86.9
Aguila [3]	Selected sample	22	12.91	None	.39	.41	None	36.70	.57		48.10	None		85.3
	Average	23	22.1			.29					41.26	.33		73.1

[1] Phalen, W. C., U. S. Geol. Survey Bull. 540, p. 530, 1912.
[2] Idem, p. 533.
[3] Butler, B. S., U. S. Dept. Interior Press Mem. 31445, April 20, 1929.

Analysts: 1 to 3, R. K. Bailey; 4, 5, 9, 10, 11, R. C. Wells; 12 to 16, Charles Milton; 6 to 8, R. E. Stevens.

These deposits contain much material that is more than 90 percent strontium sulphate, which could be shipped and manufactured with little difficulty. Development of a large industry, however, would involve the use of material containing from 70 to 90 percent of strontium sulphate. The chief impurity is silica. This dilutes the ore, but because it is inert it may be less troublesome than similar or smaller quantities of lime. Another problem is the recovery of the thinner-bedded material, of which there is a large quantity in some deposits.

The presence of more than 800,000 tons of strontium ore suggests that there is in this region the basis for a domestic strontium industry.

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BERYL

ARIZONA

MOHAVE COUNTY

By B. N. Moore

● *Aquarius Cliffs.*—Pegmatite dikes in the Aquarius Cliffs, 15 miles northeast of Wikieup and 44 miles east of Yucca, on the Atchison, Topeka & Santa Fe Railway, contain a few crystals of beryl, but the locality has no commercial interest.

● *Wright Creek.*—Beryl is a constituent of numerous pegmatite dikes, 5 to 20 feet wide, which crop out in a small area of pre-Cambrian rocks about half a mile square about 15 miles south of Peach Springs, on the Atchison, Topeka & Santa Fe Railway. The beryl occurs with tourmaline.

NEVADA

CLARK COUNTY

By Eugene Callaghan

● *Virgin Peak.*—A beryl prospect is located near the junction of two ravines on the north slope of Virgin Peak, or Bunkerville Mountain, as it is known locally, south-southeast of Bunkerville. A road extends southward from Bunkerville for 9½ miles over the dissected alluvial slope to the base of the mountain, and an obscure trail leads to the deposit, about 1,200 feet higher and 3 miles distant.

The beryl occurs in two small pegmatite lenses, one 1½ feet in maximum width as exposed and the other 3 feet. They are correspondingly limited in length and depth. The beryl occurs as fairly well defined hexagonal prisms with a maximum width of about 1 inch in a coarse quartz-feldspar matrix. Associated minerals include muscovite, garnet, black tourmaline, and small flat honey-yellow crystals. The mica occurs in books, some of which are as much as 1 foot across. The country rock is garnetiferous mica schist. The lenses are so small that probably only a few pounds of beryl could be obtained from the entire deposit as now exposed. Many other pegmatite dikes occur in the vicinity, but it is not known if they contain beryl. The claims are known as the Fool's Gold Nos. 1, 2, and 3.

SUMMARY

Beryl occurs at several places in pegmatites in the strip of pre-Cambrian rocks defined by the localities described above, but deposits of sufficient quality to be of commercial interest have not yet been discovered.

CONSTRUCTION MATERIALS

LIMESTONE AND DOLOMITE

By B. N. Moore

CALIFORNIA

KERN COUNTY

● *Tehachapi.*—Limestone occurs in greatly folded and crushed schists over an area of several square miles about 4 miles south of Tehachapi. Prior to 1928 limestone was quarried and burned in kilns at Tehachapi, on the Southern Pacific Railroad, by the Summit Lime Co. The intimate association of limestone and schist makes quarrying expensive.

SAN BERNARDINO COUNTY

● *Baxter.*—Prior to 1930 quarries were operated on a body of coarsely crystalline white limestone or marble of pre-Cambrian age that crops out in low hills half a mile north of Baxter, on the Union Pacific Railroad. The rock is folded and intruded by basic dikes, now largely serpentinized, and forms a belt 400 to 800 feet wide and about 1 mile long. Quarries are provided with spur tracks to the main line of the railroad. Production was greatest in the period 1914–18. About 65,000 tons was shipped in 1916, mainly to beet-sugar plants.

Colton.—Limestone and lime are produced by the California Portland Cement Co. from a calcitic marble quarried half a mile south of Colton.

● *Chubbuck.*—Coarsely crystalline white limestone or marble occurs as roof pendants in granitic rocks a mile south of Chubbuck (Archer) on the Atchison, Topeka & Santa Fe Railway. The rock is quarried and crushed to sizes down to dust at a mill at the quarry. Kilns at the railroad have a daily capacity of about 15 tons of quicklime. Both lime and various types of crushed limestone are shipped. The reserves are large.

● *Victorville.*—A pure calcite marble intruded by granite forms small hills 5 miles by road east of Victorville. There are many vein-like zones of contact silicate minerals which separate the marble into blocks, cause a large amount of waste, and restrict the size of quarries. The quarried material is trucked to a mill at Victorville and crushed and sized. The production goes largely to the glass trade and to manufacturers of poultry grit.

NEVADA

CLARK COUNTY

● *Apex.*—Claims have been located and exploratory work done on limestone beds forming low hills along the north side of the Union Pacific Railroad near Apex. A series of limestone beds about 700 feet thick with a few thin quartzite beds and cherty concretions crops out in four small hills over a distance of about 3 miles and from a quarter to half a mile north of the tracks. The strike is between N. 15°–30° E., and the dip 30°–45° W. The exploitable zone appears to consist of about 200 feet of finely crystalline white to light-gray thin-bedded limestone remarkably free from siliceous or ferruginous concretionary matter.

● *Ivanpah.*—From a quarry on the east side of a low hill 4 miles southeast of Ivanpah nearly 1,000 tons of high-calcium limestone was shipped about 1925. The bed is part of the Cambrian section. The reserve is small.

● *Jean.*—A quarry on the north end of Sheep Mountain, about 1 mile from Jean, on the Union Pacific Railroad, has shipped 850 tons of limestone. The rock is a coarse-grained, much-shattered dark-gray limestone with numerous small ferruginous and siliceous bodies. The quarry is now abandoned.

● *Sloan.*—A quarry has been operated since 1912 on a bed of limestone 150 feet thick that crops out on the south side of a prominent hill at Sloan, on the Union Pacific Railroad. The bed is part of the Devonian section, which contains pure limestones in many areas in southern Nevada. The limestone is horizontal and is overlain and underlain by dolomite. The content of calcium carbonate averages about 97 to 98 percent with magnesia and silica the chief impurities. In recent years (exclusive of the worst years of the depression) the annual production has been about 40,000 to 45,000 tons of raw limestone and dolomite and about 20,000 to 25,000 tons of lime, lime hydrate, dolomitic lime, and dolomitic lime hydrate.

The total production for 1928-33 was 314,006 tons. There are large reserves.

SUMMARY

Limestone and lime used in the Los Angeles area come largely from San Bernardino County, Calif. (Chubbuck, Colton, and Victorville), and Clark County, Nev. (Sloan). Limestone and dolomite quarried in Inyo County, Calif., are largely used by chemical manufacturers at Owens and Searles Lakes, and only a few tons is produced in Kern County, according to reports of the California State mineralogist. This distance of limestone producers from the consuming centers is unusual and is due to the nearly complete absence of commercial limestones in the Los Angeles area. It is interesting to note that whereas the total annual production of San Bernardino County is normally between 10,000 and 15,000 tons each of limestone and lime, the annual production from Sloan, Nev., which goes to the same market, is normally from two to three times as great.

The Boulder Dam region is assured of a large supply of excellent limestones and dolomites. The mountains that lie on both sides of the Union Pacific Railroad from Nipton north nearly to Moapa, a distance of about 100 miles, are made up largely of limestone and dolomite. The reserves of these rocks in the region are therefore very large, aside from proved reserves at Sloan and the reserves of districts already prospected.

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California State Mineralogist 15th Ann. Rept., pp. 871-883, 1919; 27th Ann. Rept., pp. 382-389, 1931.

Unusual lime operations in Far West: Rock Products Mag., April 26, 1930, pp. 41-53.

CEMENT ROCK

By B. N. Moore

Cement is now manufactured at four districts in that part of southern California under consideration—at Monolith, Kern County, by the Monolith Cement Co.; at Colton, San Bernardino County, by the California Portland Cement Co.; near Riverside (Crestmore), Riverside County, by the Riverside Portland Cement Co.; and at Victorville, San Bernardino County, by the Southwestern Portland Cement Co. The Riverside Portland Cement Co. also owns a plant at Oro Grande, San Bernardino County, a few miles north of Victorville, which is used at times of peak production.

The limestones quarried at Monolith, Colton, and Crestmore are very pure, coarsely crystalline rocks found as remnants of once extensive sediments in granitic intrusives. The limestone used by the Southwestern Portland Cement Co. contains irregular and variable amounts of lime silicates (epidote, zoisite, etc.). The successful use over a period of years of such material, together with weathered granite, schist, etc., as a source of extra silica and alumina is of interest, because it contradicts the widely accepted dictum that limestone for cement manufacture must be free of lime silicates, quartz, etc., and that the material used for the necessary silica and alumina must be shale or clay.

Cement for the Boulder Dam is supplied by all four plants in cooperation. The daily capacities of the plants range from 9,000 to 12,000 tons. In the manufacture of cement for the Boulder Dam slow-setting cements were developed. For the iron-rich type considerable amounts of iron ore were mined at the deposit near Baxter. Another type, consisting essentially of tricalcium silicate has been developed by the Southwestern Portland Cement Co. and is made by using a mixture of pure limestone, garnet rock, and quartzite.

No quarry for cement materials has ever been opened in southern Nevada, but if the markets and fuel situation near Las Vegas ever justified the consideration of a cement plant nearby, there can be no doubt that the raw materials exist in abundance.

REFERENCES

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Riverside County: California State Mineralogist 15th Ann. Rept., pp. 555–559, 1919; 25th Ann. Rept., pp. 517–519, 1929.

Kern County: California State Mineralogist 25th Ann. Rept., pp. 70–71, 1929.

GYPSUM

CALIFORNIA

By B. N. Moore

IMPERIAL COUNTY

● *Fish Mountains.*—Remnants of a once extensive bed of gypsum of Tertiary age from 50 to 150 feet thick rest on granitic rocks in the Fish Mountains of the Salton Sink. The largest and most accessible remnant forms a body about 1 mile wide, 3 miles long, and from 50 to 150 feet thick. The greater part of it is owned by the Pacific Portland Cement Co. The gypsum is worked in a large open quarry by steam shovel, which loads the broken rock into cars that carry it to the mill at Plaster City, on the Southern Pacific Railroad, 27 miles to the south. The annual production is normally about 50,000 tons or more. The reserves are large.

RIVERSIDE COUNTY

● *Midland.*—Large deposits of gypsum in highly folded and metamorphosed rocks, commonly considered of pre-Cambrian age, occur at Midland, on the Atchison, Topeka & Santa Fe Railway, where they are mined by the United States Gypsum Co. A large modern mill and a camp for employees have been erected. The gypsum passes into anhydrite below the surface croppings. The normal production is 50,000 tons or more annually, the reserves are large.

NEVADA

CLARK COUNTY

● *Arden.*[90]—The United States Gypsum Co. and the Blue Diamond Co. have mined large quantities of gypsum from beds that lie in the Supai formation and overlying Kaibab limestone 8 to 12 miles west of Arden. Locally the beds may reach 75 feet in thickness but are commonly 5 to 15 feet. The gypsum passes into anhydrite at distances of 50 to 100 feet from surface croppings. The principal deposit of the United States Gypsum Co. appears to be exhausted, and the company has removed part of the tracks leading from the deposit to the mill at Arden.

The Blue Diamond Co. is mining a 14-foot bed of gypsum that crops out around the sides of several small hills near the summit of a ridge in sec. 32, T. 21 S., R. 59 E., and sec. 5, T. 22 S., R. 59 E. The gypsum is gently folded and passes into anhydrite at distances of 50 to 200 feet from croppings on the hillsides. The annual production in recent years has been about 50,000 to 70,000 tons, which is shipped to Los Angeles. The reserves are large.

Croppings of the formations carrying gypsum beds may be followed many miles in this district, and exploration along known horizons should reveal very large reserves.

● *Muddy Mountains.*[91]—South of the Narrows of Muddy Creek, in Clark County, Nev., a bed of gypsum crops out more or less continuously for 4½ miles, from 3 to 7½ miles from the railroad and highway. The gypsum is interbedded with red sandy shale in the upper part of the Chinle formation (Triassic), dips steeply eastward, and forms a ridge from 15 to 85 feet high. Within a red gypseous zone about 200 feet thick relatively pure bedded gypsum ranges from 90 to less than 10 feet in thickness, reaching a maximum near the north and south ends of the outcrop. Exact measurements are difficult, but the average thickness of bedded gypsum appears to be about 30 feet.

Some development work has been done near the north end of the deposit, but very little if any material has been shipped. Four samples collected from the walls of a tunnel show a fair grade of gypsum (G1, G2, G3, and G4 in table below).

The approximate reserve in this deposit above nearby ravines is estimated to be about 1,500,000 tons.

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[90] By B. N. Moore.
[91] By Eugene Callahan and W. W. Rubey.

Impure gypsum, perhaps reworked from the Chinle bed, crops out three-quarters of a mile from the railroad (G5).

Analyses of gypsum from Muddy Mountains, Nev.

[Charles Milton, analyst]

	G1	G2	G3	G4	G5
Insoluble	2.4	1.5	2.3	0.2	8.0
R_2O_3	Trace	Trace	Trace	Trace	.3
CaO	31.8	32.2	31.6	32.8	29.9
H_2O	20.3	20.4	20.5	20.8	19.3
SO_3	43.5	44.4	43.3	44.9	40.4
Total	98.0	98.5	97.7	98.7	97.9
Calculated gypsum	93.5	95.5	93.1	96.6	86.8

G1. Series of chip samples to represent 7.4 feet of gypsum beds near face of tunnel, 4 miles by road south of highway through Narrows of Muddy Creek.
G2. Series of chip samples to represent 9.0 feet of gypsum beds adjacent to G1.
G3. Series of chip samples to represent 10.0 feet of gypsum beds adjacent to G2 and near portal of tunnel
G4. Chip samples to represent large spherical white lumps in gypsum bed at tunnel face adjacent to G1.
G5. Channel sample taken 6 feet from portal of tunnel, three-quarters of a mile by road south of highway through Narrows of Muddy Creek, to represent 5.0 feet of best-looking portion of detrital gypsum.

At several localities near the south end of the Muddy Mountains the Horse Spring formation contains thick beds of massive gypsum. These deposits are particularly noticeable along Bitter Spring Wash, near the point at which the road turns north out of the wash toward the old colemanite workings in White Basin; along the road to the old West End borax mine at the head of Callville Wash, 3 miles east of the mine; and along the fault contact between the Paleozoic limestones and the Horse Spring formation 1¾ miles north-northwest of the old West End mine. No effort seems to have been made to develop the gypsum at any of these places.

SUMMARY

Beds of gypsum occur in several sedimentary formations in this region. Gypsite or granular gypsum formed by evaporation of gypsum-bearing water is also found at places and has been mined from dry-lake beds near Gypsite, Kern County, and Amboy, San Bernardino County, Calif. There are numerous deposits of both rock gypsum and gypsite which have not been described, but the districts above-mentioned are outstanding. Even though the gypsum passes into anhydrite below the outcrops, there are very large resources within easy access and of good quality.

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REFRACTORY AND CERAMIC MATERIALS

SILICA

CALIFORNIA

SAN BERNARDINO COUNTY

● *Oro Grande.*[92]—A bed of quartzite about 100 feet thick crops out about 1 mile northeast of Oro Grande and may be traced for nearly 5 miles around the south side of Oro Grande Mountain. Two operators quarry this material for shipment to Los Angeles, where it is crushed and used as ganister in making refractory silica brick. The production ranges from 10 to 20 carloads a month, depending on the activity of the steel mills and smelters. The reserves are very large.

NEVADA

CLARK COUNTY

● *Bard.*[92]—A 300-foot cross-bedded sandstone member of the Supai formation forms a prominent cliff along the mountain front several miles west of Bard. Because it is cross-bedded, there is great variation in size of the grains and in composition. The sand is essentially quartz with a small amount of heavy iron-bearing minerals and some lime cement.

In 1934 one operator in the district was producing molding sand for shipment to steel mills in the Los Angeles district. The reserves are inexhaustible. No attempts have been made to use this material for a glass sand.

● *Muddy Mountains.*[93]—Extensive deposits of quartz sand crop out northeast and southwest of the Muddy Mountains. In the northeastern area there are immense sand deposits in the thick Jurassic (?) sandstone and overlying Overton fanglomerate and in surficial dune deposits derived from these older formations.

Silica sand is being quarried from the Overton fanglomerate 5 miles south of Overton and trucked 3.8 miles to a washing plant on the St. Thomas branch of the Union Pacific Railroad. Certain beds are said to run 99.2 percent SiO_2, but a series of chip samples taken to represent the 100 feet of beds being quarried was found to contain a slightly lower percentage (S4 in table below). About 10 or 20 tons of the washed sand from this locality was shipped in the spring of 1934.

Several carloads of sand was also being shipped at the same time from the dune deposits in Magnesite Wash, 2 miles south of Overton. This loose sand is said to be suitable for the manufacture of colored bottle glass.

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[92] By B. N. Moore.
[93] By Eugene Callaghan and W. W. Rubey.

A washing plant is being built 1 mile north of Overton, and a road that extends 8 miles to the west and south is being constructed by the Nevada Silica Sand Co. to handle silica sand from a quarry that is being opened in the midst of large exposures of Jurassic (?) sandstone. Two samples of the sandstone exposed at the quarry site were collected, of which one (S2) has been analyzed.

Three or four carloads of silica sand has been mined and shipped by C. D. Wyatt from a quarry in the Jurassic (?) sandstone, on the west side of the Muddy Mountains, along the old borax road from White Basin to Crystal Siding. Three chip samples, collected to represent the various types of sandstone exposed here, have been analyzed (WS1, WS2, WS3).

Southwest of the Muddy Mountains some exploratory work has been done in deposits of silica sand in the Overton fanglomerate. Three prospect pits are located alongside the road from the old West End borax mine to Las Vegas, at the head of Callville Wash, 5 to 6 miles by road west of the mine.

Analyses of sand and clay from Muddy Mountains, Nev.

[R. E. Stevens, analyst]

	S2	S3	S4	WS1	WS2	WS3
SiO_2	95.80	64.40	96.77	94.10	94.38	94.77
Al_2O_3	2.38	13.64	1.55	3.39	3.08	2.46
Fe_2O_3	.20	3.08	.07	.08	.13	.16
TiO_2	.08	--------	.04	.07	.06	.04
CO_2	--------	None	--------	--------	--------	--------
Total	98.46	81.12	98.43	97.64	97.65	97.43

S2. "Chip" sample of yellow sandstone of typical rock exposed extensively near Nevada Silica Sand Co.'s quarry, 8 miles by road west and south from Overton.
S3. Gray clay exposed alongside new road of Nevada Silica Sand Co. 5½ miles from railroad.
S4. Series of chip samples taken to represent the 100 feet of sandstone exposed in the north face of large pit 5 miles south of Overton.
WS1. Chip sample to represent white sandstone at Wyatt claim, in window of Jurassic (?) sandstone on west side of Muddy Mountains, along old borax road from White Basin to Crystal Siding.
WS2. Chip sample to represent pink sandstone at Wyatt claim.
WS3. Chip sample to represent yellow sandstone at Wyatt claim.

FELDSPAR

By B. N. Moore

ARIZONA

MOHAVE COUNTY

Kingman.—Feldspar has been mined in the Hualpai Mountains south of Kingman by the Consolidated Feldspar Co., of Trenton, N. J.; and in the Cerbat Range, to the north, by the Gold Cliff Central Co., which shipped 2,100 tons to the Los Angeles market in 1927.

NEVADA

CLARK COUNTY

Nipton.—From a quarry on the west slope of Crescent Peak, 8 miles east of Nipton on the Union Pacific Railroad, about 1,000 tons of feldspar has been mined from a pegmatite body and shipped. A small reserve remains. (See p. 55.)

SUMMARY

From what is known of the geology of southern Nevada, southeastern California, and western Arizona, other deposits of feldspar undoubtedly exist, but because of distance from markets they have received little attention. Most of the feldspar used in the southern California ceramic plants has been obtained from scattered deposits in Riverside and San Diego Counties, which are more accessible than those farther east.

REFERENCES

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FLUORSPAR

By B. N. Moore

ARIZONA

YUMA COUNTY

● *Castle Dome.*—Fluorspar is the principal gangue mineral of many of the silver-lead veins of the Castle Dome district. Production started in 1902 but has been sporadic, and the value of the total output has amounted to only about $30,000. Although a coarse gravel or lump spar can be easily mined, sufficient lead is present to prevent its use in steel mills. The galena occurs sporadically, however, and at times of high prices some production is made by hand sorting. According to mine owners, the small size of the Pacific coast market offers no inducement for installing cleaning or concentrating equipment. (See p. 30.)

CALIFORNIA

SAN BERNARDINO COUNTY

● *Afton.*—Fluorspar veinlets are numerous over an area of several square miles of Tertiary volcanic rocks about 5 miles south of Afton on the Union Pacific Railroad. The veins have a general trend of about N. 45° E. The largest vein is from 6 inches to 2 feet thick and may be traced nearly 2,000 feet on the surface. A pit at one point shows the vein to be formed of a rather cavernous, drusy fluorspar containing many fragments of wall rock. Some material has been shipped, but reserves of minable material are probably small.

●*Baxter.*—A deposit of fluorspar half a mile south of Baxter was examined and found to consist of a slight amount of fluorspar in greatly crushed limestone.

●*Nipton.*—A fluorspar deposit 4 miles east of Nipton consists of veinlets of spar as much as 6 inches thick, in gneiss. (See p. 55.)

NEVADA

NYE COUNTY

●*Beatty.*—Granular and powdered fluorspar has for several years been mined in a small way from the Daisy mine, in the Bare Mountains 6 miles southeast of Beatty. The fluorspar occurs as a purple sand and powder mixed with clay, apparently the leached product of a limestone impregnated with fluorite. In places residual masses of unleached limestone occur. This material forms a large body in a complexly faulted zone in Paleozoic limestone. It has been explored to a depth of 135 feet, and drifts show that it extends about 250 feet laterally and has a maximum thickness of about 25 feet. It is soft enough to be mined by hand tools. A mill has been erected at Beatty for producing concentrates running above 90 percent CaF_2. As much as 750 tons has been shipped in one year. The reserves in sight amount to about 5,000 tons.

Other veins occur in the nearby region but are not large enough to mine economically. A deposit on the south side of the mountains known as the Diamond Queen was located on an outcrop resembling material from the Daisy mine, but extensive exploration failed to find more than the surface trace. (See p. 68.)

MINERAL COUNTY

●*Mount Montgomery.*—Fluorspar veins striking N. 25° W. and dipping 75° E. occur in andesites near the Owenyo line of the Southern Pacific Railroad about 2 miles south of Mount Montgomery. The main vein is as much as 6 feet thick, but the fluorspar is mixed with large amounts of silica in very intimate fashion.

SUMMARY

Fluorspar, apparently related to Tertiary metallization, is widely distributed in this region, but in most places the quantity is insignificant or undesirable impurities are present.

REFERENCES

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CLAYS

CALIFORNIA

By B. N. Moore

KERN COUNTY

● *Cache Creek.*—The Filtrol Co. is mining a bed of bentonite in Cache Creek Canyon about 10 miles east of Monolith. The bentonite is apparently a bed of altered volcanic ash in a series of volcanic tuffs and lavas. The bed is about 7½ feet thick and underlies more than 100 acres. The reserves are large, although the total extent of the bed is not known.

● *Jawbone Canyon.*—The Vitrefax Corporation is mining an altered rhyolite in Jawbone Canyon, about 10 miles by road from Cantil. Hydrothermal alteration has removed varying amounts of the original constituents of the rock over an area about half a mile in diameter, and rock containing varying amounts of silica, alumina, soda, and potash is mined and blended to produce ceramic bodies. The production in 1934 at the time of visit was several cars a week.

● *Muroc.*—Large amounts of bentonite have been mined and shipped by the Muroc Clay Co. since 1927 from a bed of bentonite 7 feet thick in a low hill 11 miles north of Muroc station. The bentonite, which has formed from the alteration of volcanic ash, underlies an area of about 100 acres.

RIVERSIDE COUNTY

Alberhill-Corona.—A great variety of clays, including plastic and semiplastic fireclays, are mined in the Alberhill-Corona district, in the Elsinore trough, and form the basis for the ceramic industry of southern California. No study of this district was made during the investigation.

SAN BERNARDINO COUNTY

● *Bryman.*—About 3½ miles east of Bryman on the Atchison, Topeka & Santa Fe Railway a very greatly altered porphyritic lava is mined by the Velvet White Filler Co. The washed product is used as a filler in paints, etc., and is composed of sericite and quartz, exceptionally finely divided, and is not a clay, despite reports to that effect. The bodies are very irregular, but the main quarry is located in one that is about 300 feet long and 50 to 100 feet wide.

● *Hart.*—Clays that have the properties of mixtures of ball and china clays are found in altered rhyolite at Hart, 18 miles east of Ivanpah. The properties are owned by the Coors Co., of Inglewood, Calif., and the Standard Sanitary Manufacturing Co. During 1926 the Standard Sanitary Co. produced about 1,500 to 2,000 tons. A fair reserve remains. (See p. 48.)

● *Hector.*—Bentonite in irregular masses along bedding planes and in faulted zones has been formed by the alteration of tuffaceous sediments of tilted Tertiary lake beds 3 miles northwest of Hector. The California Talc Co. produces several cars a week. The manner of occurrence makes it impossible to estimate reserves.

NEVADA

CLARK COUNTY

● *Muddy Mountains.*[94]—A bed of gray clay crops out alongside the new road that is being constructed west and south from Overton by the Nevada Silica Sand Co. This bed of clay, about 75 feet thick, lies at the base of the Overton fanglomerate and is traceable continuously for at least 5 miles southeast from the road. A sample (S3) was collected from a prospect pit alongside the road (p. 170).

ESMERALDA COUNTY

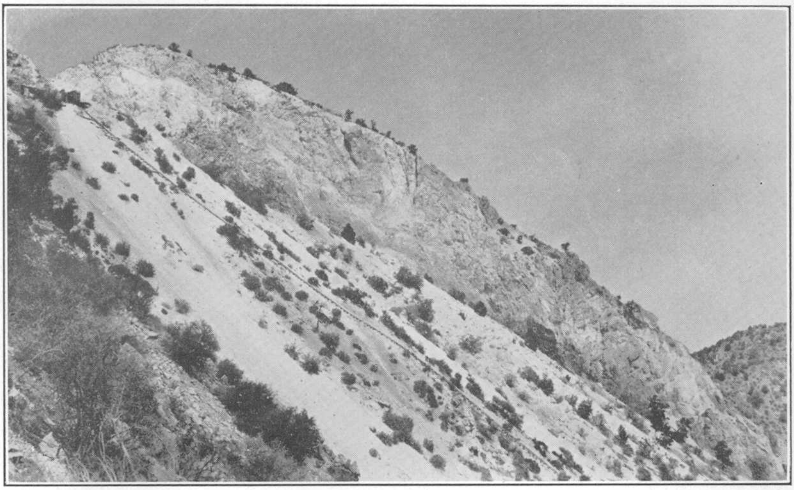
● *Cuprite.*—The greatly altered tuffs near Cuprite have been used by the Whiting Mead Co., of Los Angeles, for china clay in the manufacture of sanitary porcelain. The bodies are irregular in size and occurrence. (See p. 57.)

LINCOLN COUNTY

● *Boyd.*[94]—A deposit of clay that was worked intermittently between 1920 and 1930 lies just under the peak of a sharp, narrow ridge about 1,100 feet vertically higher than the tracks of the Union Pacific Railroad in Rainbow Canyon, 14 miles south of Caliente and 1½ miles north of Boyd station. To judge from the size of the quarries, considerable quantities of the material have been shipped. The property consists of four patented lode claims, a mill site, and four unpatented claims which are held by the American Clay Co., of Nevada.

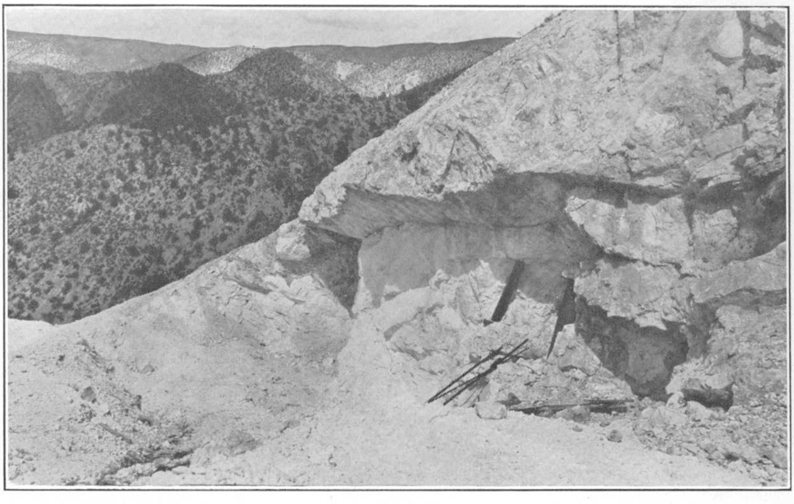
The deposit occurs as part of a lens which is thickest at the southwest end of the quarry and appears to pinch out in the face of the cliff to the northeast (pl. 14, *A*, *B*). The quarry face is 25 feet high in the north quarry, which is partly underground, and is somewhat higher in the south quarry (fig. 50). The slopes are precipitous in every direction. The clay is the result of hydrothermal alteration of a volcanic rock, apparently a tuffaceous rhyolite, for there are "ghosts" of fragments and quartz phenocrysts remaining. The surrounding rocks are also altered but appear to contain more secondary silica. The clay is creamy white, hard, and does not slump when wet.

[94] By Eugene Callaghan.



A. GENERAL VIEW OF CLAY DEPOSIT NEAR BOYD, NEV.

Outcrop of altered volcanic rock containing the lens of clay of the American Clay Co. of Nevada, on the east side of Rainbow Canyon. The white clay lens appears at the upper left just to the right of the head of the tramway.



B. DETAILS OF CLAY DEPOSIT NEAR BOYD, NEV.

Quarry face 25 feet high in north quarry at workings of American Clay Co. of Nevada. The clay lies under the prominent slip plane. Above is harder, more silicified altered rhyolite.

The results of chemical analyses are given in the accompanying table. Some if not all of the material contains variable quantities of alunite.

All the material mined was shipped. The clay was let down on an inclined tram about 550 feet to a loading bin and trucked to the rail-

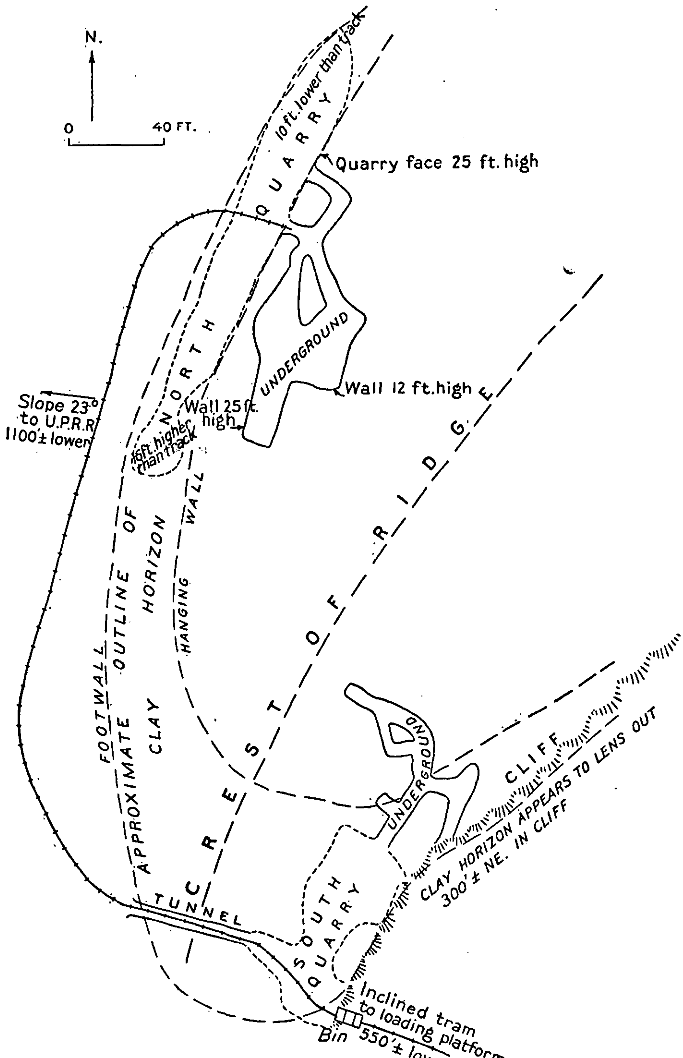


FIGURE 50.—Sketch map showing workings on clay deposit near Boyd, Nev.

road a mile away. As may be ascertained from figure 50, a large part of the deposit is still in place, but it is not known whether all the material is of merchantable grade. From very rough estimates it appears that about 800,000 cubic feet of the material of the grade shipped is available. The overburden is largely between 20 and 50 feet thick.

Chemical analyses of clay near Boyd, Nev.

	14-A	14-B	AC-3		14-A	14-B	AC-3
SiO_2	44.20	58.40		SO_3	2.74	8.58	16.00
Al_2O_3	36.00	13.00		H_2O	16.85	17.70	
K_2O			5.92	Undetermined	.21	2.32	

14-A, 14-B. Samples taken by E. C. Hoag and analyzed by Union Pacific Railroad Co. Furnished through courtesy of Mr. Hoag. Exact locations not given.
AC-3. Thickness of 7.0 feet on south face of north underground quarry. White altered rock with pink porcelaneous areas in irregular veinlets and spots.

NYE COUNTY

● *Ash Meadows.*[95]—Large quantities of bleaching clay and bentonite are found in the lake beds of the Ash Meadows region and have been mined and shipped to oil refineries in southern California. The main operator is now the Coen Co., which operates properties that belong to various oil companies and extend over an area about 3 miles long and 2 miles wide. The bleaching clays occur as large irregular bodies in horizontally stratified lake beds. Production has varied greatly with the demands of the oil industry, and from 10 to 80 carloads a month have been shipped. The reserves are very large.

● *Beatty.*—An altered rhyolite tuff occurring 8 miles east of Beatty, in the Bare Mountains, has been described as suitable for use in place of Cornish stone in ceramic manufacture. The most-altered material occupies an area of less than 5 acres. The rock is veined with halloysite and is slightly stained in places with cinnabar. (See p. 172.)

SUMMARY

Most of the Tertiary sediments of this region contain altered tuffaceous material possessing bleaching properties, and to enumerate all the deposits that have been located would take much space. Similarly there are many bentonite deposits. Competition has eliminated all but those easily accessible and of high quality. The vast area of sediments, however, suggests that there are probably many deposits yet to be uncovered.

The main source of clays of ceramic grade for the Los Angeles region is the Alberhill-Corona district. This district is deficient in ball and china clays. Materials are found at scattered places in the desert regions, chiefly in altered siliceous lavas, which are suitable for certain types of porcelain ware, but these must stand the competition of imported English china and ball clays and of Florida kaolin and other clays from the eastern United States.

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[95] By B. N. Moore.

CYANITE, DUMORTIERITE, ETC.

By B. N. Moore

ARIZONA

YUMA COUNTY

● *Quartzsite.*—A dumortieritized zone occurs in schists of igneous origin about 3 miles south of Quartzsite. The zone is characterized by the development of large amounts of quartz in which are numerous veinlets of dumortierite and cyanite. No commercial bodies have yet been found.

CALIFORNIA

IMPERIAL COUNTY

● *Ogilby.*—A deposit of cyanite is present in low hills about 3 miles northeast of Ogilby on the Southern Pacific Railroad. The body consists of finely granular quartz containing as much as about 25 percent of light-blue cyanite in wide, flat crystals, mostly from a quarter to half an inch long but some reaching 6 inches. The body is irregular and has been eroded into several hills separated by alluviated ground. It is about a quarter of a mile wide and 1 mile long. Quarries are located in the southernmost hill, where the quartz and cyanite are more free of pyrite. The cyanite is quarried and shipped to Los Angeles by the Vitrefax Corporation for use in the manufacture of mullite refractories. The dimensions of the deposit indicate that reserves are large.

Pyrophyllite occurs at the north end of the deposit and is worked and sold for use as talc. (See p. 34.)

SUMMARY

Deposits of the cyanite-dumortierite-sillimanite-andalusite group of minerals are rare in this region. To the north of it in Inyo County, Calif., occurs the unique andalusite deposit of the Champion Spark Plug Co., and in Pershing County, Nev., there is a large deposit of dumortierite.

REFERENCES

Wilson, E. D., An occurrence of dumortierite near Quartzsite, Ariz.: Am. Mineralogist, vol. 14, pp. 373–381, 1929.

California State Mineralogist, 27th Ann. Rept., pp. 455–457, 1931.

TALC

By B. N. Moore

CALIFORNIA

SAN BERNARDINO COUNTY

● *Silurian Mountains.*—Talc ocurs at many places in the Silurian Mountains south of Death Valley, but only the deposit of the Pacific

Coast Talc Co. was visited. This deposit consists of a series of disconnected lenses, the remnants of limestone or dolomite beds in rocks so intensively granitized as to resemble in places superficially sheared "diorites." The lenses are as much as several hundred feet long, 100 feet deep, and 10 to 20 feet thick. The purest talc occurs in the center of the bodies, and the outer parts contain much tremolite. Talc of various grades is produced. The highest quality goes to cosmetic manufacturers, other grades to rubber manufacturers, and the highly tremolitic material to the ceramic trade. The production to date has been about 100,000 tons.

SUMMARY

Talc has been found near Zabriskie, Tecopa, and Keeler, in Inyo County, and near Riggs and Silver Lake, in San Bernardino County. In 1918 there were eight producers operating; in 1933 there were five. Competition with foreign talc and the small size of the local market restrict the output to considerably less than full capacity.

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California State Mineralogist, 27th Ann. Rept., pp. 399–401, 1931.

VOLCANIC ASH

By Eugene Callaghan

NEVADA

LINCOLN COUNTY

● *Panaca.*[96]—A deposit of volcanic sand or ash, locally known as "silica sand", occurs in the Panaca formation near the southwest corner of sec. 19, T. 1 S., R. 68 E., west of the upper end of Cathedral Gulch, about 4 miles northwest of Panaca. It is about half a mile west of a paved highway, but there is no connecting road. Some 40 cars of this material is reported to have been shipped to Los Angeles 10 or 15 years ago, but no information was obtained on the utilization of the material.

The deposit occurs as a sandy, unconsolidated bed about 9 feet thick, which is exposed for about 1,500 feet in the banks of the wash west of Cathedral Gulch (fig. 51). It is cut off by a fault on the west side of Cathedral Gulch but extends at least 600 feet to the west and probably much farther. The overburden of tuff and gravel is between 17 and 40 feet thick over most of the area, but in the

[96] Westgate, L. G., and Knopf, Adolph, Geology and ore deposits of the Pioche district, Nev.: U. S. Geol. Survey Prof. Paper 171, pp. 23–26, 1932.

valley of the wash it is probably not over 10 feet thick in an area 200 feet square. It seems reasonable to estimate that the deposit underlies an area 600 by 1,000 feet with a thickness of 9 feet, which should yield more than 5,000,000 cubic feet of ash. Another bed

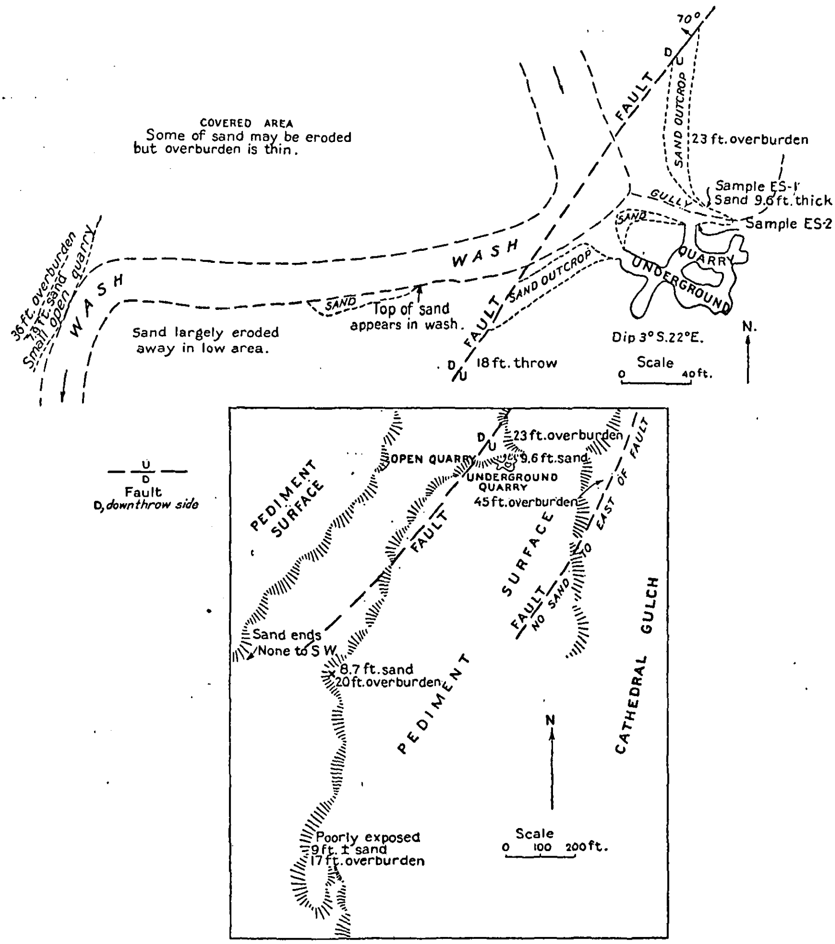

FIGURE 51.—Sketch map showing quarry on volcanic-ash deposit near Panaca, Nev.

of this material more than 8 feet thick lies about 1,000 feet to the northeast and is exposed for some 700 feet along a steep bank. It contains more carbonate cement than the main deposit.

The ash is light gray to white, fine-grained (largely between 0.1 and 0.3 millimeter), angular and friable but stands in vertical walls. It is composed of clear volcanic glass with mostly less than 10 percent of quartz and feldspar fragments. A fine carbonate dust occurs even in the most friable material, and some, especially in the northern deposit (not shown in fig. 51), is partly cemented by carbonate.

Partial chemical analyses made in the laboratory of the United States Geological Survey are given below.

Chemical analyses of volcanic ash near Panaca, Nev.

[R. E. Stevens, analyst]

	ES-1	ES-2	ES-3		ES-1	ES-2	ES-3
SiO_2	72.16	72.83	68.00	MgO	(1)		
Al_2O_3	9.88	12.96	12.00	TiO_2	(1)	0.08	
Fe_2O_3	.78	.24	1.76	CO_2	(2)	(2)	(2)
CaO	.94			H_2O	5.52		

1 Trace.
2 Present.
ES-1. Upper gray part of bed 4.6 feet thick on north side of gully near north portal of underground quarry.
ES-2. Lower white part of bed 5.0 feet thick at east side of north portal of underground quarry.
ES-3. Lower 5.4 feet of bed about 1,500 feet northeast of main deposit.

DIATOMITE

By Eugene Callaghan

NEVADA

LINCOLN COUNTY

Panaca.[97]—A deposit of powdery white material, largely diatomite, occurs in sec. 10, T. 2 S., R. 68 E., 1 mile east of Panaca

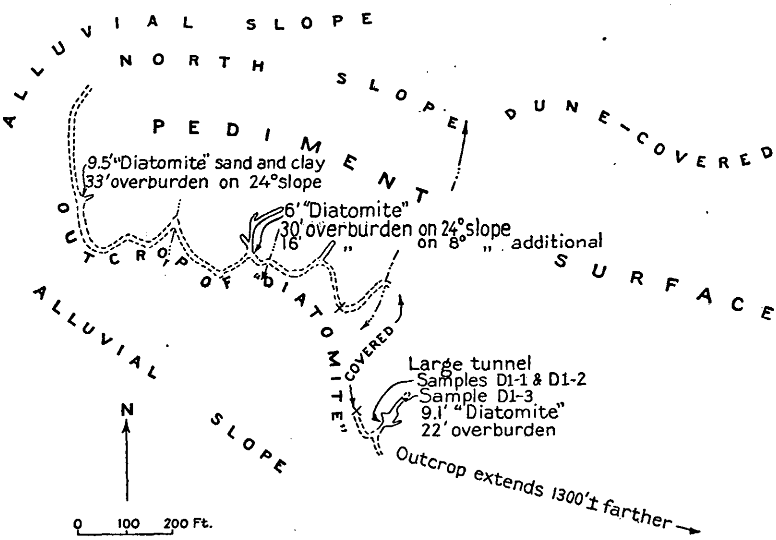

FIGURE 52.—Sketch map showing workings on diatomite deposit near Panaca, Nev.

and a few hundred feet from the highway leading to Modena. The diatomite occurs as a bed that crops out for 2,300 feet, as partly shown in figure 52, along the south slope of a long, low flat-topped ridge of the Panaca formation. The deposit has been prospected by

[97] Westgate, L. G., and Knopf, Adolph, op. cit., p. 24.

several cuts and five short tunnels. No records of any shipments were obtained.

The total thickness of the bed ranges between 6 and 10 feet, including lenses of sand and other impurities. In places it appears to be cut out entirely. The overburden is mostly between 22 and 40 feet thick. The deposit is not exposed on the north side of the ridge, but the bed probably averages at least 200 feet in a north-south direction, so that it may be estimated that at least 2,000,000 cubic feet of diatomite and associated impurities is available.

According to a laboratory report by K. E. Lohman, of the United States Geological Survey, it consists of about 80 percent of diatoms with fragments of volcanic glass and crystals and fine material consisting of diatom fragments, clay (?), and fine ash. It could be used as a sound and heat insulator or absorbent but not for filtration medium according to existing standards.

The best-appearing material (sample DI–1) is very fine-grained and white. Much of the bed is gritty, contains calcareous nodules or pipes, and grades into or is in sharp contact with lenses of sand. Partial chemical analyses made in the laboratory of the United States Geological Survey are given in the table below.

Chemical analyses of diatomite near Panaca, Nev.

[Charles Milton, analyst]

	D1	D2	D3		D1	D2	D3
SiO_2	82.59	81.15	79.47	CaO	0.70	1.76	1.30
R_2O_3 (chiefly Al_2O_3)	5.07	5.97	7.49	MgO	.77	.88	.40

D1. Whitest and best appearing part of deposit at large tunnel, thickness 4.0 feet.
D2. Basal part of deposit at same locality, thickness 2.6 feet. Somewhat darker than that above.
D3. Uppermost 2.5 feet near face of tunnel at same locality. Harder and more gritty than that below.

FUELS

By D. F. Hewett

COAL

NEVADA

ESMERALDA COUNTY

Coaldale.—Two small mines and numerous prospecting pits have been sunk on beds of coal of middle Tertiary age about 4 miles south of Coaldale, on the Southern Pacific Railroad. On account of its high ash content (30 to 40 percent) the coal has not found a ready market, and little has been shipped.

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Spurr, J. E., Coal deposits between Silver Peak and Candelaria, Esmeralda Co., Nev.: U. S. Geol. Survey Bull. 225, pp. 289–292, 1903.

Hance, J. H., The Coaldale coal field, Esmeralda County, Nev.: U. S. Geol. Survey Bull. 531, pp. 313–322, 1913.

UTAH

IRON AND KANE COUNTIES

● *Colob-Kanab.*—There are several well-explored coal fields in Utah, but the most accessible to Las Vegas is that which lies southeast of Cedar City, 240 miles by rail distant. At least two mines are operated in a small way for a large part of the year, 4 and 8 miles, respectively, southeast of Cedar City, and several more are operated farther southeast but more remote from the railroad.

At one mine the explored bed is about 5½ feet thick, but it includes two bony layers about 1 foot thick. The coal is rated as subbituminous, and the quality is fair; laboratory tests indicate that it may be converted to coke. Under fair demand, this coal could probably compete successfully with the better coal from Castlegate, Utah, about 500 miles by rail from Las Vegas.

REFERENCE

Richardson, G. B., The Harmony, Colob, and Kanab coal fields, southern Utah: U. S. Geol. Survey Bull. 341, pp. 379–400, 1909.

PETROLEUM

NEVADA

CLARK COUNTY

● *Las Vegas.*—The discoveries of oil in southwestern Utah in recent years have aroused interest in nearby parts of Nevada that show similar geologic features. About 12 miles southwest of Las Vegas, in the SW¼ sec. 31, T. 21 S., R. 60 E., a well has been drilled to a depth of 1,200 feet in beds of the Supai formation. Although the stratigraphy of the area is probably as favorable for the occurrence of oil as that in southwestern Utah, the structural features are unfavorable, as it is known that large faults occur nearby.

UTAH

WASHINGTON COUNTY

● *Virgin.*—There has been considerable interest and activity in the search for petroleum in southern Utah and Nevada for about 15 years. Since the discovery of oil in the Virgin field, about 1924, wells have been drilled in at least six other areas that appear to show structural conditions favorable to oil. Thus far the Virgin field has yielded several thousand barrels of oil a year. From what is known of the occurrence of oil in this field and of the geologic conditions in the area nearby, it seems possible that other small oil fields may be found, but there is no definite indication of large productive fields.

REFERENCE

Bassler, Harvey, and Reeside, J. B., Jr., Oil prospects in Washington County, Utah: U. S. Geol. Survey Bull. 726, pp. 87–107, 1922.

WATER

By D. F. Hewett

NEVADA

CLARK COUNTY

Las Vegas.—Most of the area under review receives less than 10 inches of rainfall annually, and as a result there are few perennial streams, and the region is deficient in water supplies. With the exception of the Colorado River, the outstanding source of good water is the artesian wells near Las Vegas. Within the artesian basin, which includes about 97 square miles, there are at present about 300 wells, from 225 of which water flows at the surface. Most of these wells range from 300 to 800 feet in depth, but several are about 1,100 feet. The discharge of flowing wells ranges from 0.10 to 6.0 cubic feet a second, and the estimated total discharge from all wells is about 35 cubic feet a second. As this water is of good quality, it is obviously the basis for the location of the town of Las Vegas and is vital to its existence.

Semiannual measurements of the discharge of about 50 wells during the last 15 years, made by George Hardman, of the Agricultural Experiment Station of Nevada, show that the discharge from most of the wells has steadily declined 35 to 50 percent from an early maximum. The data necessary to show what amount of water may be drawn safely from the artesian wells are not now available, but existing data show that serious drafts upon the water supply are being made. If cheap power draws industries to the Boulder Dam area, they will use water and will wish to be assured concerning the quantity and quality of the supply. A comprehensive study of the artesian water supply of Vegas Valley is urgently needed.

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Bixley, F. L., and Hardman, G., Development of water supplies for irrigation in Nevada by pumping from underground sources: Nevada Univ. Agr. Exper. Sta. Bull. 212, p. 38, 1928.

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