CONTRIBUTIONS TO ECONOMIC GEOLOGY, 1908, PART I.

C. W. HAYES and WALDEMAR LINDGREN, *Geologists in charge.*

INTRODUCTION.

By C. W. HAYES, *Chief geologist.*

This bulletin is the seventh of a series, including Bulletins 213, 225, 260, 285, 315, and 340, Contributions to Economic Geology for 1902, 1903, 1904, 1905, 1906 (Part I), and 1907 (Part I), respectively. These bulletins are prepared primarily with a view to securing prompt publication of the economic results of investigations made by the United States Geological Survey. By means of the bibliographies accompanying the several groups of papers they also serve as a guide to the economic publications and afford a better idea of the work which the Survey as an organization is carrying on for the direct advancement of mining interests throughout the country than can readily be obtained from the more voluminous final reports.

The first two bulletins of this series included numerous papers relating to the economic geology of Alaska. In view of the rapid increase of economic work, both in Alaska and in the States, and the organization of a division of Alaskan mineral resources distinct from the division of geology, it was in 1905 considered advisable to exclude all papers relating to Alaska. These were brought together in a separate volume entitled "Report of progress of investigations of mineral resources of Alaska in 1904," Bulletin 259. A similar segregation of papers relating to Alaska has since been made and published annually.

During 1906 a further change in the arrangement of the economic bulletin seemed desirable. The former section of iron ores and nonmetallic minerals was divided and M. R. Campbell was placed in charge of a new section devoted to the investigation of fuels. This change in Survey organization was used as a basis for a separation of the economic bulletin, based on subjects. The present bulletin

is therefore restricted to the work of the Survey in 1908 in the metals, structural materials, and other nonmetals except fuels. A separate bulletin will be issued later (Bulletin 381) relating to Survey work on coal, lignite, peat, oil, and gas.

The papers included in the present volume are such only as have a direct economic bearing, all questions of purely scientific interest being excluded.

The papers are of two classes—(1) preliminary discussions of the results of extended economic investigations, which will later be published by the Survey in more detailed form; (2) comparatively detailed descriptions of occurrences of economic interest, noted by geologists of the Survey in the course of their field work, but not of sufficient importance to necessitate a later and more extended description.

The papers have been grouped according to the subjects treated and each group has been issued as soon as ready, in advance of the complete bulletin. At the end of each section is given a list of previous publications on that subject by this Survey. These lists will be serviceable to those who wish to ascertain what has been accomplished by the Survey in the investigation of any particular group of mineral products. They are generally confined to Survey publications, though a few titles of important papers published elsewhere by members of the Survey are included.

Material assistance in the preparation of this volume has been rendered by W. C. Phalen, and to him is largely due the promptness of its publication.

The results of the Survey work in economic geology have been published in a number of different forms, which are here briefly described:

1. *Papers and reports accompanying the Annual Report of the Director.*—Prior to 1902 many economic reports were published in the royal octavo cloth-bound volumes which accompanied the Annual Report of the Director. This form of publication for scientific papers has been discontinued and a new series, termed Professional Papers, has been substituted.

2. *Bulletins.*—The bulletins of the Survey comprise a series of paper-covered octavo volumes, each containing usually a single report or paper. These bulletins, formerly sold at nominal prices, are now distributed free of charge to those interested in the special subject discussed in any particular bulletin. This form of publication facilitates promptness of issue for economic results, and most economic reports are therefore published as bulletins. Their small size, however, precludes the use of large maps or plates, and reports containing large illustrations are issued in the series of professional papers.

3. *Professional Papers.*—This series, paper covered but quarto in size, is intended to include such papers as contain maps or other illustrations requiring the use of a large page. The publication of the series was commenced in 1902, and the papers are distributed in the same manner as are the bulletins.

4. *Monographs.*—This series consists of cloth-bound quarto volumes, and is designed to include exhaustive treatises on economic or other geologic subjects. Volumes of this series are sold at cost of publication.

5. *Geologic folios.*—Under the plan adopted for the preparation of a geologic map of the United States the entire area is divided into small quadrangles, bounded by certain meridians and parallels, and these quadrangles, which number several thousand, are separately surveyed and mapped. The unit of survey is also the unit of publication, and the maps and descriptions of each quadrangle are issued in the form of a folio. When all the folios are completed, they will constitute a Geologic Atlas of the United States.

A folio is designated by the name of the principal town or of a prominent natural feature within the quadrangle. It contains topographic, geologic, economic, and structural maps of the quadrangle, and in some cases other illustrations, together with a general description.

Under the law copies of each folio are sent to certain public libraries and educational institutions. The remainder are sold at 25 cents each, except such as contain an unusual amount of matter, which are priced accordingly.

Circulars containing complete lists of these folios, showing the location of the quadrangle areas they describe, their prices, etc., are issued from time to time and may be obtained on application to the Director of the United States Geological Survey. The following list shows the folios issued since January 1, 1908, and in an advanced state of preparation, also the economic products discussed in the text of each, the products of greatest importance being printed in italic:

List of geologic folios issued between January 1, 1908, and July 1, 1909, showing mineral resources described.

No.	Name of folio.	State.	Area in square miles.	Author.	Mineral products described as occurring in area of folio.
154	Winslow	Ark.-Ind. T.	969	Purdue, A. H	Limestone, clay, iron, oil, gas, zinc, lead, coal, underground water.
155	Ann Arbor	Mich	885	Russell, I. C.; Leverett, F.	Limestone, road material, clay, *marl*, cement, peat, underground water.
156	Elk Point	S. Dak.-Nebr.-Iowa.	878	Todd, J. E	Clay, sand, cement, volcanic ash, lignite, *underground water.*
157	Passaic	N. J.-N. Y.	906	Darton, N. H.; Bayley, W. S.; Salisbury, R. D.; Kümmel, H. B.	*Iron*, graphite, copper, building stone, road material, *pottery clay*, brick clay, lime, sand and gravel, peat, underground water.
158	Rockland	Me	215	Bastin, E. S	*Lime*, road material, cement, *granite*, clay, sand, peat, gravel.
159	Independence	Kans	950	Schrader, F. C	*Oil, gas*, coal, building stone, road material, lime, glass sand, cement materials, clay, underground water.
160	Accident-Grantsville	Md.-Pa.-W. Va.	460	Martin, G. C	*Coal*, fire clay, lime, building stone, road material, iron.
161	Franklin Furnace	N. J	226	Spencer, A. C.; Salisbury, R. D.; Kümmel, H. B.; Palache, Chas.; Wolff, J. E.	*Iron*, zinc, graphite, limestone, slate, clay, sand and gravel, building stone, road material.
162	Philadelphia (Norristown, Germantown, Chester, Philadelphia).	Pa.-N. J.-Del.	915	Bascom, F.; Clark, W. B.; Darton, N. H.; Kümmel, H. B.; Salisbury, R. D.; Miller, B. L.; Knapp, G. N.	Building stone, road material, *lime*, magnesium carbonate, soapstone, iron, gravel, sand, *pottery clay*, *feldspar*, *brick clay*, marl.
163	Santa Cruz	Cal	950	Branner, J. C.; Newsome, J. F.; Arnold, R.	Gold, *bituminous rock*, *petroleum*, building stone, road material, lime, cement material, diatomaceous shale, sand, underground water.
164	Belle Fourche	S. Dak	849	O'Harra, C. C.; Darton, N. H.	Gypsum, lime, clay, building stone, bentonite, *underground water.*
165	Aberdeen - Redfield (Northville, Aberdeen, Redfield, Byron).	S. Dak	3,383	Todd, J. E	Lignite, clay, sand, gravel, salt, gas, *underground water.*
166	El Paso	Tex	889	Richardson, G. B.	Tin, *clay*, *cement*, flux, lime, sand, gravel, *underground water.*
167	Trenton	N. J.-Pa	912	Bascom, F.; Darton, N. H.; Kümmel, H. B.; Clark, W. B.; Miller, B. L.; Salisbury, R. D.	*Pottery clay*, brick clay, *molding sand*, building sand, gravel, *marl*, building stone, road material, lime, copper, barite.
168	Jamestown - Tower (Jamestown, Eckelson, Tower).	N. Dak	2,460	Willard, D. E	Underground water.

List of geologic folios in preparation.

Name of folio.	State.	Area in square miles.	Author.	Mineral products described as occurring in area of folio.
Engineer Mountain	Colo	236	Cross, W	Limestone and building stone.
Foxburg	Pa	225	Shaw, E. W	*Coal, oil, gas*, sand, clay.
Johnstown	Pa	228	Phalen, W. C	Coal, clay, limestone, cement material, concrete materials, building stone, road materials, glass sand, iron ore.
Mercersburg-Chambersburg.	Pa	458	Stose, G. W	*Iron*, manganese, white clay, barite, *lime*, cement material, sand, clay, building stone, marble, road material, underground water.
Warren	Pa	226	Butts, Chas	Oil, *gas*, *petroleum*, clay, coal, building stone.
Watkins Glen-Catatonk	N. Y	1,770	Williams, H. S.; Tarr, R. S.; Kindle, E. M.	Sand, gravel, clay, underground water.

INVESTIGATIONS RELATING TO NONMETALLIC MINERAL RESOURCES AND IRON ORES.

By C. W. HAYES, *Chief geologist.*

PUBLICATIONS ISSUED AND IN PREPARATION.

During the year 1908 the following publications, consisting wholly or in part of the results of investigations on the nonmetallic mineral resources of the United States, were issued by the Survey. Publications relating to coal, lignite, peat, etc., except folios, are not included in this list.

Professional Papers:

56. Geography and geology of a portion of southeastern Wyoming, with special reference to coal and oil, by A. C. Veatch.

Bulletins:

322. Geology and oil resources of the Santa Maria oil district, Santa Barbara County, Cal., by Ralph Arnold and Robert Anderson.
329. Organization, equipment, and operation of the structural-materials testing laboratories at St. Louis, Mo., by R. L. Humphrey.
331. Portland cement mortars and their constituent materials; results of tests made at the structural-materials testing laboratories, Forest Park, St. Louis, Mo., 1905–1907, by R. L. Humphrey and William Jordan, jr.
338. The iron ores of the Iron Springs district, southern Utah, by C. K. Leith and E. C. Harder.
340. Contributions to economic geology, 1907. Part I.—Metals and nonmetals, except fuels. C. W. Hayes and Waldemar Lindgren, geologists in charge.
346. Structure of the Berea oil sand in the Flushing quadrangle, Harrison, Belmont, and Guernsey counties, Ohio, by W. T. Griswold.
349. Economic geology of the Kenova quadrangle, Kentucky, Ohio, and West Virginia, by W. C. Phalen.
350. Geology of the Rangely oil district, Rio Blanco County, Colo., with a section on the water supply, by H. S. Gale.
351. The clays of Arkansas, by J. C. Branner.
354. The chief commercial granites of Massachusetts, New Hampshire, and Rhode Island, by T. N. Dale.
355. The magnesite deposits of California, by F. L. Hess.
357. Preliminary report on the Coalinga oil district, Fresno and Kings counties, Cal., by Ralph Arnold and Robert Anderson.
359. Magnetite deposits of the Cornwall type in Pennsylvania, by A. C. Spencer.
364. Geology and mineral resources of the Laramie Basin, Wyoming; a preliminary report, by N. H. Darton and C. E. Siebenthal.
365. The fractionation of crude petroleum by capillary diffusion, by J. E. Gilpin and M. P. Cram.

(Road materials of southern and eastern Maine, Bulletin No. 33, U. S. Department of Agriculture, by Henry Leighton and Edson S. Bastin.)

The following folios are those in which nonmetallic products of considerable importance are described. The substances printed in italics are of most importance.

Folios:

154. Winslow (Ark.-Ind. T.), by A. H. Purdue. Limestone, clay, iron, oil, gas, zinc, lead, coal, underground water.
155. Ann Arbor (Mich.), by I. C. Russell and F. Leverett. Limestone, road material, clay, *marl*, cement, peat, underground water.
156. Elk Point (S. Dak.-Nebr.-Iowa), by J. E. Todd. Clay, sand, cement, volcanic ash, lignite, *underground water*.
157. Passaic (N. J.-N. Y.), by N. H. Darton, W. S. Bayley, R. D. Salisbury, and H. B. Kümmel. *Iron*, graphite, copper, building stone, road material, *pottery clay*, brick clay, lime, sand and gravel, peat, underground water.
158. Rockland (Me.), by E. S. Bastin. *Lime*, road material, cement, *granite*, clay, sand, peat, gravel.
159. Independence (Kans.), by F. C. Schrader. *Oil*, *gas*, coal, building stone, road material, lime, glass sand, cement materials, clay, underground water.
160. Accident-Grantsville (Md.-Pa.-W. Va.), by G. C. Martin. *Coal*, fire clay, lime, building stone, road material, iron.
161. Franklin Furnace (N. J.), by A. C. Spencer, R. D. Salisbury, H. B. Kümmel, Charles Palache, and J. E. Wolff. *Iron*, *zinc*, graphite, limestone, slate, clay, sand and gravel, building stone, road metal.
162. Philadelphia (Pa.-N. J.-Del.), by F. Bascom, W. B. Clark, N. H. Darton, H. B. Kümmel, R. D. Salisbury, B. L. Miller, and G. N. Knapp. Building stone, road material, *lime*, magnesium carbonate, soapstone, iron, gravel, sand, *pottery clay*, *feldspar*, *brick clay*, marl.
163. Santa Cruz (Cal.), by J. C. Branner, J. F. Newsome, and R. Arnold. Gold, *bituminous rock*, *petroleum*, building stone, road material, lime, cement material, diatomaceous shale, sand, underground water.

Reports for which the field work has been completed and which are in press or in an advanced state of preparation are the following:

Iron and manganese.

Iron ores, fuels, and fluxes of the Birmingham district, Alabama, by E. F. Burchard, Charles Butts, and E. C. Eckel. (Bulletin 400.)

The iron-ore supplies of the United States, by C. W. Hayes. (In Bulletin 394.)

The manganese deposits of the United States and foreign countries, by E. C. Harder.

Petroleum and natural gas.

Geology and oil resources of the Coalinga district, California, by Ralph Arnold and Robert Anderson. (Bulletin 398.)

Systematic comparison of the crude petroleums in the United States, by D. T. Day.

Oil and gas in the Sewickley, Carnegie, and Clarion quadrangles, Pennsylvania, by M. J. Munn.

Geology and water resources of the northern portion of the Black Hills and adjoining regions in South Dakota and Wyoming, by N. H. Darton. (Professional Paper 65.)

Building stones, road metal, etc.

The granites of Vermont, by T. Nelson Dale.

Granites of the southeastern Atlantic States, by T. L. Watson.

Cement and concrete materials.

Geology and water resources of the northern portion of the Black Hills and adjoining regions in South Dakota and Wyoming, by N. H. Darton. (Professional Paper 65.)

Structural materials in parts of Oregon and Washington, by N. H. Darton. (Bulletin 387.)

The fire-resistive properties of various building materials, by R. L. Humphrey. (Bulletin 370.)

The structural materials in the District of Columbia region, by N. H. Darton.

Investigations of concrete and reinforced concrete at ten technological institutions, by R. L. Humphrey and R. V. Engstrom.

The cement materials and industry of the United States, by E. C. Eckel.

Clays.

Geology and water resources of the northern portion of the Black Hills and adjoining regions in South Dakota and Wyoming, by N. H. Darton. (Professional Paper 65.)

Economic geology of the Johnstown quadrangle, Pennsylvania, by W. C. Phalen.

Gypsum and magnesite.

Geology and water resources of the northern portion of the Black Hills and adjoining regions in South Dakota and Wyoming, by N. H. Darton. (Professional Paper 65.)

A reconnaissance of the gypsum deposits of California, by F. L. Hess.

Miscellaneous.

Geology of the Maine pegmatites, by E. S. Bastin.

The occurrence of diamonds in the United States and elsewhere, by G. F. Kunz.

The phosphate deposits of the United States, by F. B. Van Horn.

FIELD WORK.

As in previous years, a large part of the work on nonmetalliferous minerals during 1908 was carried on in connection with other investigations, chiefly areal surveys. By reason of the character of these deposits they can not generally be studied with advantage in advance of detailed topographic mapping, and their relations to the areal distribution of the rock formations are such that detailed areal geologic surveys are also generally necessary.

Iron ores, manganese and aluminum ores.—A systematic review of all available information relating to the iron-ore supplies of the United States was made and a report containing a brief description of the distribution and geologic relations of the ores, with estimates of tonnage, was prepared by C. W. Hayes for the Conservation Commission. This report will be published with other reports of similar nature as Bulletin 394.

Field work on the manganese deposits of the United States was completed by E. C. Harder, and a detailed report, which contains also a summary of all available information concerning foreign deposits, is in preparation.

Field work has been continued on the Appalachian iron ores by Mr. Harder in Virginia and by Mr. Burchard in Tennessee, Georgia,

and Alabama. It is proposed to prepare as soon as possible a monographic report on this district.

The developments in the Lake Superior district have been followed closely by C. R. Van Hise and his assistants, and a report summarizing the various monographs already published and bringing information and conclusions regarding the relations of the iron ores down to date is now in preparation. This report contains important conclusions as to the origin of the ores and marks a decided advance toward the establishment of a quantitative basis for geologic theories.

Structural materials.—Cooperation has been continued with the technologic branch in the study of building materials by N. H. Darton and E. F. Burchard, and valuable data on this important subject have been obtained.

The systematic work on the New England granites was completed by T. Nelson Dale, and the third report on this subject is in preparation. It is proposed now to take up a similar investigation of the marble and marble-quarrying industry.

The report by T. L. Watson on the granites of the Southern Atlantic States has been completed and will be issued during the year.

The field work on the roofing slates of Arkansas has been completed by A. H. Purdue and a report is being published by the State.

Oil and gas.—Detailed surveys on oil and gas fields have been continued by M. J. Munn in western Pennsylvania, by J. A. Taff in Oklahoma, by C. W. Washburne in Colorado, and by Ralph Arnold in California. A reconnaissance of certain reported occurrences of oil in Nevada was made by Robert Anderson. Papers relating to oil and gas are this year included in the second part of Contributions to economic geology for 1908, together with papers on other mineral fuels.

Phosphates.—A report on the phosphate deposits of the United States was prepared by F. B. Van Horn for the Conservation Commission and will be included in Bulletin 394 with other reports of a similar nature.

INVESTIGATIONS RELATING TO DEPOSITS OF METALLIFEROUS ORES.

By WALDEMAR LINDGREN, *Geologist in charge.*

PUBLICATIONS OF THE YEAR.

During the year the following publications on subjects connected with the investigations of deposits of metalliferous ores (except iron and manganese) in the United States have been issued by the Geological Survey:

Professional Papers:

62. The geology and ore deposits of the Cœur d'Alene district, Idaho, by F. L. Ransome and F. C. Calkins.
63. Economic geology of the Georgetown quadrangle, together with the Empire district, Colorado, by J. E. Spurr and G. H. Garrey; with general geology by S. H. Ball.

Bulletins:

328. The gold placers of parts of Seward Peninsula, Alaska, by A. J. Collier, F. L. Hess, P. S. Smith, and A. H. Brooks.
337. The Fairbanks and Rampart quadrangles, Yukon-Tanana region, Alaska, by L. M. Prindle, with sections by F. L. Hess and C. C. Covert.
340. Contributions to economic geology, 1907, Part I: Metals and nonmetals except fuels. C. W. Hayes, Waldemar Lindgren, geologists in charge.
345. Mineral resources of Alaska in 1907, by A. H. Brooks and others.
347. The Ketchikan and Wrangell mining districts, Alaska, by F. E. and C. W. Wright.
353. Geology of the Taylorsville region, California, by J. S. Diller.
358. Geology of the Seward Peninsula tin deposits, Alaska, by Adolph Knopf.
364. Geology and mineral resources of the Laramie Basin, Wyoming, by N. H. Darton and C. E. Siebenthal.

Folios:

161. Franklin Furnace, New Jersey, by A. C. Spencer, R. D. Salisbury, H. B. Kümmel, Charles Palache, and J. E. Wolff. Contains descriptions of iron, zinc, and manganese deposits.
163. Santa Cruz, California, by J. C. Branner, J. F. Newsome, and Ralph Arnold. Contains descriptions of gold deposits.

The following list comprises reports which are now in the press or in the editor's hands:

Professional Paper:

66. Geology and ore deposits of the Goldfield district, Nevada, by F. L. Ransome.

Bulletins:

374. Mineral resources of the Kotsina-Chitina region, Alaska, by F. H. Moffit and A. G. Maddren.

375. The Fortymile district, Yukon-Tanana region, Alaska, by L. M. Prindle.

379. Mineral resources of Alaska, 1908, by A. H. Brooks and others.

384. A geological reconnaissance in northern Idaho and northwestern Montana, by F. C. Calkins.

397. Mineral deposits of the Cerbat Range, Black Mountains, and Grand Wash Cliffs, Mohave County, Arizona, by F. C. Schrader.

The Innoko gold placer district, Alaska, by A. G. Maddren.

The mineral resources of the Nabesna-White district, Alaska, by F. H. Moffit and Adolph Knopf.

Geology and mineral resources of the Solomon and Casadepaga quadrangles, Seward Peninsula, Alaska, by P. S. Smith.

Geology and ore deposits of the Bullfrog district, Nevada, by F. L. Ransome, W. H. Emmons, and G. H. Garrey.

The following list comprises reports for which the field work has been completed, but which have not yet been transmitted to the press:

Resurvey of the Leadville mining district, Colorado, by S. F. Emmons and J. D. Irving.

The Tertiary auriferous gravels of the Sierra Nevada, by Waldemar Lindgren.

Copper deposits of the Butte district, Montana, by W. H. Weed.

Economic geology of the Park City mining district, Utah, by J. M. Boutwell and L. H. Woolsey.

Reconnaissance of deposits of metalliferous ores of New Mexico, by Waldemar Lindgren, L. C. Graton, and C. H. Gordon.

The copper deposits of Shasta County, Cal., by L. C. Graton.

Geology and ore deposits of the Phillipsburg quadrangle, Montana, by W. H. Emmons and F. C. Calkins.

Notes on some mining districts in the southern part of Humboldt County, Nev., by F. L. Ransome.

Reconnaissance of mining districts in western Elko, Eureka, and Lander counties, Nev., by W. H. Emmons.

Geology and ore deposits of the Dahlonega district, Georgia, by Arthur Keith.

The ore deposits in the vicinity of Lake City, Colo., by J. D. Irving and H. Bancroft.

FIELD WORK.

GENERAL STATEMENT.

The field and office work of the section of metalliferous deposits was continued during 1908 on a plan similar to that used during the preceding year, the relatively small amount of money available for the work prohibiting any enlargement of operations.

As during previous years, the supervision of the collection of metal statistics has occupied a part of the time of Messrs. Boutwell, Graton, Hess, Lindgren, and Siebenthal. These duties, of course, took some time from the purely geologic work, but each year demonstrates more clearly that a thorough knowledge of all occurrences and conditions of production of a metal is indispensable to the economic geologist who desires to make a specialty of that metal. The attempt is made to reduce to a minimum the purely mechanical work done by the geologist for such purposes. He will retain the supervision and the reviewing, and this connection with practical work in his branch, far from being a detriment, will enable him to obtain a much better knowledge of the resources of the nation; moreover, the data collected, if intelligently handled, will allow him to draw many important geologic conclusions.

WORK BY LOCALITIES.

The following notes summarize the geologic work by members of the Survey in 1908, so far as the metalliferous deposits, except iron, are concerned:

ALASKA.

For the operations in Alaska, which, under the direction of A. H. Brooks, cover a wide field, the reader is referred to the report on the mineral resources of Alaska in 1908, which has just been issued as Bulletin 379.

ARIZONA.

No field work was undertaken in the mining districts of Arizona during 1908, but the report of a reconnaissance of the deposits in Mohave County, by F. C. Schrader, was completed during the year, and will, as indicated above, be published as Bulletin 397.

CALIFORNIA.

The mapping of the Randsburg quadrangle, in connection with special studies of the gold deposits in that district, was begun by

F. L. Hess during the last months of the year. The field work of this complicated area is not yet completed and will be continued in 1909.

The preparation of a report on the copper deposits of Shasta County, by L. C. Graton, aided by B. S. Butler, was continued and it is expected that the report will be issued as a professional paper at the close of 1909.

COLORADO.

A topographic map of the vicinity of Breckenridge, on the scale of 1:24,000, was prepared by the topographic branch during the summer of 1908, and in September F. L. Ransome began the study of the geology and ore deposits, which, however, was interrupted by the early snows of October. The investigation will be completed in 1909.

In the month of July J. M. Hill devoted two weeks to a reconnaissance of the mining districts in the eastern part of Gunnison County, an account of which will be found elsewhere in this bulletin. H. Bancroft, as assistant to Whitman Cross, spent some weeks of the fall in completing an investigation of the mines near Lake City, Hinsdale County.

NEVADA.

During the early summer of 1908 F. L. Ransome completed the field work in the Goldfield district and devoted the following months to a reconnaissance of mining districts in southern Humboldt County, as well as to an examination of the Yerington copper-mining district, an account of which will be found on other pages of this bulletin.

During the same time W. H. Emmons made a reconnaissance of the little-known mining districts of western Elko County and adjacent parts of Lander and Eureka counties.

OREGON.

In connection with areal geologic work, J. S. Diller, assisted by G. F. Kay, continued the examination of the gold-quartz veins, copper deposits, and placers of southwestern Oregon. A summary of the mining developments has been prepared for the present bulletin. In connection with other work D. F. MacDonald visited the Bohemia mining district, and a brief report on its geology and deposits is also contained in this volume.

SOUTH DAKOTA.

F. L. Hess visited the Black Hills during the summer and has prepared an account of the tin, tungsten, and tantalum deposits of that region, which is published in this bulletin.

UTAH.

In July, August, and September B. S. Butler completed the geologic mapping of the Frisco special area in Beaver County, and the investigation of the mines in that vicinity will, it is expected, be finished during the field season of 1909.

APPALACHIAN STATES.

In November, 1908, H. D. McCaskey spent some weeks examining the mines of the Dahlonega belt in Cherokee County, Ga.

GOLD AND SILVER.

NOTES ON THE ECONOMIC GEOLOGY OF SOUTHEASTERN GUNNISON COUNTY, COLORADO.

By J. M. Hill.

INTRODUCTION.

During the latter part of July, 1908, the writer had an opportunity to visit some of the mining camps of southeastern Gunnison County, Colo. The following report is a summary of the results obtained. Little time was available, and as a consequence the material for an economic paper is meager. No topographic survey of this county has been made, and no good maps are available. The sketch map (Pl. I) used as a base for this work is taken from a county map, on which some corrections were found necessary. The mines in these districts were for the most part closed, partly owing to the low price of silver, but most of the accessible workings were visited. Much of the information used in this report was given by local miners and operators and, where possible, verified by the writer, who wishes here to acknowledge the courtesy shown him by all the mining men of the district.

GEOGRAPHY.

The Continental Divide here follows the Sawatch Mountains, which form the eastern boundary line of Gunnison County. From the main range numerous spurs run out to the plateau region south and west of Tomichi Creek. Between these spurs there are several large streams, the main one in the southern part being Tomichi Creek. This stream heads near the center of the east boundary line of the area mapped on Plate I, just under the crest of the divide. It runs southward for about 18 miles and then turns to the northwest to join Gunnison River just west of Gunnison. Cochetopa

Creek, a southern branch, joins Tomichi Creek about 2 miles below Parlin, after running northward for 7 miles.

The next largest drainage system is that of Quartz Creek, which flows through the central part of the area. This stream heads a mile north of the headwaters of Tomichi Creek and flows in a general southwesterly direction to that creek at Parlin. Quartz Creek has three large branches—North Fork, Ohio Creek, and Alder Creek, named from east to west. Minor branches are South Fork and Armstrong Gulch. Only one tributary enters Quartz Creek from the south.

To the north of the Quartz Creek drainage basin there is a high divide, north of which the streams all flow into the headwaters of Gunnison River. Willow Creek is the most eastern stream of this system, and the town of Tincup is situated at the junction of its three branches. Lottis Creek, to the west, is the only other stream of this drainage area shown on the map.

The Continental Divide averages well above 12,000 feet in elevation, and of the peaks within the area of the sketch map Fairview Peak, Cross Mountain, and Fossil Ridge are more than 11,000 feet high. The general slope, as shown by the drainage lines, is southwestward in the area south of an east-west line between Fairview Peak and Alpine Pass, and northward in the area north of the same line. The appended table gives the elevations of the towns:

Elevations of towns in southeastern Gunnison County, Colo.

Town.	Elevation (feet).	Authority.
Parlin	7,942	Denver and Rio Grande R. R. survey.
Sargents	8,875	Do.
Ohio City	8,546	Colorado and Southern Ry. survey.
Pitkin	9,190	Do.
Quartz	9,642	Do.
Tincup	9,650	Aneroid.
White Pine	10,000	Do.

There are two narrow-gage railroads in this area. The Montrose branch of the Denver and Rio Grande Railroad follows Tomichi Creek from Sargents to Gunnison, and the Gunnison branch of the Colorado and Southern Railway crosses the Sawatch Range at Alpine tunnel, at the head of Quartz Creek, and follows that stream to Parlin, whence it parallels the Denver and Rio Grande to Gunnison. On both of these roads there is daily service each way.

Many good wagon roads and trails traverse this region, and two passes over the range are in use. Alpine or Cottonwood Pass, to the north, is crossed twice daily by the mail stage from Buena Vista to

Tincup. Monarch Pass, to the south, is not used as much, but gives a direct road from White Pine or Sargents to the mining town of Monarch, on the east side of the range.

The principal supply points for these districts are Pitkin and Ohio City. They are both on Quartz Creek, so that they get fair railway service most of the year, and are centrally located. Tincup supports two stores, but there are many vacant houses in town. White Pine is almost deserted, though a few men are still working in the vicinity. Tomichi is a town of the past, only one half-ruined building remaining on its site. Sargents and Parlin, in the lower Tomichi Valley, are supported more by ranchers than by mining men, as the miners of the southwestern districts obtain their supplies from Gunnison.

GEOLOGY.

Pre-Cambrian rocks cover by far the larger portion of southeastern Gunnison County, forming the Sawatch Range and its east-west spurs. South of Tomichi Creek is a plateau, which rises about 200 feet above the stream, composed entirely of red and gray coarse-textured granites. Within this pre-Cambrian basement area there are several isolated patches of sedimentary beds, cut off usually by faults, though in one place erosion was the main factor in dividing two areas. All the formations have been much disturbed, faulting, folding, and intrusion having played an important part in their character, present distribution, and structure.

STRATIGRAPHY.

PRE-CAMBRIAN ROCKS.

The pre-Cambrian rocks are widely distributed and their structure is very complex. They consist of red and gray granites, some almost pegmatitic, and of gneiss and schists of various kinds ranging from amphibolitic to muscovitic. Three miles east-northeast of Tincup, near the crest of the main range, there is a small body of very highly metamorphosed limestones and quartzites. These are entirely inclosed by gneiss and are probably a part of the pre-Cambrian. West of Pitkin, where the section given below was measured, the granite is somewhat porphyritic and grades into a granite schist, between which and the unmetamorphosed sedimentary beds is a series of biotite schists, some of which appear to be metamorphosed quartzites. At one place in this formation a small lens of pure quartzite was seen.

PALEOZOIC ROCKS.

The subjoined section is typical of the Paleozoic rocks in this region and gives the local names of certain characteristic formations.

Section in the Pitkin "lime belt," Gunnison County, Colo.

	Feet.
Green and red shales, somewhat carbonaceous in upper portions	70
Thin-bedded dark-blue limestone	250
Red grits	20
Massive blue limestone	30
Massive gray dolomite	60
Carboniferous (?), massive blue limestone and black chert	300
Gray and buff dolomite	20
"Buckskin" limestone, buff, very fine texture	20
Mottled red shales, locally known as pink shale	10
"Fairview" shale, mottled yellow	40
Gray dolomite	18
"Parting" quartzite, mottled white	18
Silurian (?), massive dark-gray limestone and white chert	185
Cambrian (?), white quartzite	120
Pre-Cambrian, schists, granite, etc.	

The oldest unmetamorphosed sedimentary formation of this area is a quartzite of widespread occurrence, which is found at the bottom of the section in all places. The white color of this formation is very characteristic and its texture is constant. Weathered surfaces often appear somewhat pinkish, but fresh fractures are usually white. Just above this formation is a bed of conglomerate, the pebbles of which are derived from the underlying quartzite. This conglomerate grades into a gray limestone, whose characteristics make it comparatively easy to recognize. It is usually about 100 feet thick, though in several places 190 to 200 feet were seen. It is rather light gray in color and contains a great deal of white chert, particularly in the basal portion. Between this limestone and the younger calcareous beds is a very constant bed known as the "parting" quartzite, which is somewhat darker than the quartzite at the base of the section and shows brown and pink mottling, even on freshly broken surfaces.

The lower portion of the limestones above the "parting" quartzite shows several minor differences in different localities. At most of the places where this part of the section was exposed the following characteristics were noted: Just above the quartzite is a thin bed (rarely over 20 feet thick) of gray dolomite of rather coarse texture, almost invariably followed by a series of shales. At the best exposure these shales were 50 feet thick, but they are more commonly very thin or entirely absent. The lower part of the shales is yellow, but they are mottled with red in the central portion, and are very red and more calcareous at the top. Above these shales are two thin

beds of light-buff color. The lower is an almost pure limestone of very fine texture, called from its color the "buckskin" limestone. The bed above is a grayer buff and contains a large percentage of magnesium. It is of coarser texture than the limestone, and exhibits marked conchoidal fracture. These two beds together are nowhere more than 40 feet in thickness, and are in many places much thinner. Immediately above the buff or middle dolomite comes the heaviest bed of the section—a dark-blue, massive limestone, containing a large amount of black chert. It averages over 250 feet in thickness, though thinner in some places. It stands out in many bluffs and forms the cap rock of a large part of the Pitkin lime basin. Near the top of this formation there is usually a bed of massive gray dolomitic limestone, which is of very coarse texture and has decidedly different characteristics from the limestone above and below it. Above the massive blue limestone there is in a few places a thin bed, 20 feet or less in thickness, of red sand grits, the grains of which are in places rather large. This is followed by a series of thin-bedded blue limestones and shales, the former in many places attaining a considerable thickness. Shales are present near the top of this series, and are locally somewhat carbonaceous. Lignitic coal occurs in a few localities, and at one place a mixture of what appeared to be bog iron was seen with a mass of carbonaceous material.

One formation, not shown in the section because of its uncertain age, is a conglomerate composed of bowlders and pebbles of quartzite, dolomite, and gray and yellow limestone in a matrix of pink and white sand. It is somewhat indurated, but weathers rapidly. This conglomerate was seen in a small exposure on the south side of Quartz Creek, opposite Pitkin, and nowhere else. It overlies the massive blue limestone and must therefore be younger than that formation. That it is a remnant of a formation more recent than any in the section seems possible on account of the yellow limestone in it, as no rocks were found in this area which weather with this color. No correlation of this section with that of other localities was possible. It resembles in some ways, however, the section at Leadville, as described by Emmons.[a]

The same general succession is to be found in the exposures of the Tincup "lime belt," though some of the members are absent and there are differences in thickness of the beds represented.

INTRUSIVE ROCKS.

In many places in this region there are dikes and sheets of felsitic porphyry and granite porphyry of intrusive origin. This intrusive porphyry does not resemble the pre-Cambrian porphyritic granite,

[a] Emmons, S. F., Geology and mining industry of Leadville, Colo.: Mon. U. S. Geol. Survey, vol. 12, 1886, pp. 53–69.

as it is gray to white in color and contains a much smaller percentage of dark minerals. The groundmass of the granite porphyry is commonly rather coarse in texture, the crystals of feldspar, biotite, and quartz being easily recognizable in hand specimens. In some places, however, the groundmass is so fine grained that no megascopic determination of its composition is possible: to such rock the term "felsitic porphyry" is applied.

LATE GRAVELS.

There has been some glaciation in the higher parts of the Sawatch Range. Glacial drift was noticed in particular in the east fork of Willow Creek about 1 mile east of Tincup, in the upper Tomichi Valley, north of White Pine, and in the valley of the middle fork of Quartz Creek, near Sherrod. All the stream beds have considerable accumulations of gravels, particularly in their wider portions.

West of Tomichi Dome is a basin entirely covered with fine soil, derived from the adjacent hills, which seems to be exceptionally fertile.

STRUCTURE.

The structure of this region is very complex and only the most prominent features can be outlined. To the north of the main east-west divide—that is, in the Tincup and Cross Mountain districts (see section A–B, fig. 1)—there are two areas of sedimentary rocks, each cut off on the east by faults. The beds dip to the east and the surface slopes at a less angle than the dip of the beds, thus exposing the youngest formations at the base of the hills. In both areas these younger beds abut against the pre-Cambrian rocks, with a stream at the junction. (See Pl. I.) In the Tincup "lime belt," as the sedimentary areas are locally called, the beds at the south end dip about 20° NE., but the dip changes to 45° E. in the central portion and becomes almost vertical at the north end of the area mapped. The strike of the beds at the north end is N. 10° W.; at the south end the strike becomes more nearly east and west, as the end of the basin is reached. The numerous sheets and dikes of quartz-bearing porphyry in this belt complicate the structure locally.

South of the divide, in the area covered by the Quartz Creek, Gold Brick, and Carbonate districts, there are two bodies of sedimentary beds, as shown in figure 1. The central or Pitkin area forms a basin (see section C–D and E–F, fig. 1), the beds dipping into it from all directions. Ohio Creek follows what is apparently the top of an anticline, cutting through the sedimentary rocks into the pre-Cambrian. The same rocks are exposed on both sides of the top of the valley walls, though the beds to the west are considerably higher

than those to the east. The east side of this area fans out on the top of the west valley wall of the north fork of Quartz Creek, and the erosion of this stream probably accounts for the long tongue of the series that extends to the southeast. East of the north fork nothing but pre-Cambrian gneiss and granite is exposed to the top of the main range. A fault following Hall Gulch has repeated the series. To the north of this fault the sedimentary beds are exposed in the bottom of the valley, but to the south they lie near the crest of the ridge, about 900 feet above the stream. There is also a fault within the Pitkin lime belt, striking about parallel with the one just de-

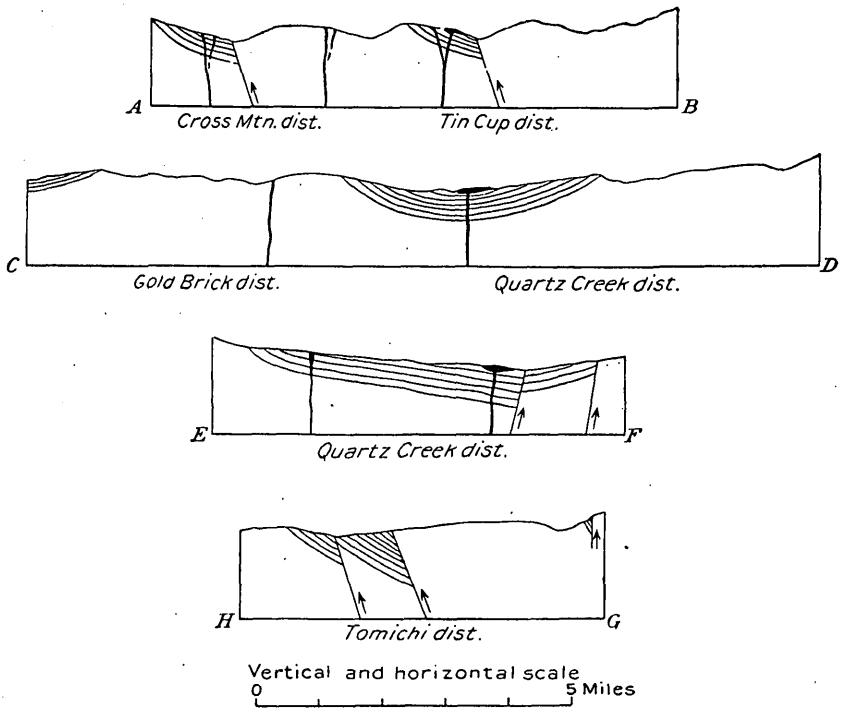


FIGURE 1.—Generalized structure sections in southeastern Gunnison County, Colo. For lines of sections see Plate I.

scribed. It is small and runs out in a low anticline before it reaches Armstrong Gulch. In this area there are several dikes and sheets of quartz-bearing porphyry, and one stock which stands up as a prominent knob on the divide between Hall and Armstrong gulches, about 1½ miles southeast of Fairview Peak.

The Tomichi district lies largely in the pre-Cambrian region and the structure is very complicated. The district includes two small areas of sedimentary beds. (See section H–G, fig. 1.) There are several dikes of granite porphyry, all of which have a general north-south trend and parallel the main structure of the gneiss and granite.

Numerous small faults trending in the same direction are shown in the underground mine workings. The more prominent faults cut across the general structure and define the area of the sedimentary exposures. (See fig. 1.)

In all the pre-Cambrian areas indicated on Plate I the general structure of the granites, gneisses, and schists follows approximately north-south lines. This trend has determined in large measure the strike of the intrusive rocks, as they usually follow the general structure, and of the ore deposits of the pre-Cambrian areas, which occur almost invariably in small faults or slips, taking the form of lenses and veins with a north-south strike.

MINERAL RESOURCES.

HISTORY.

As early as 1875 mention was made by Raymond [a] of the discovery of silver ores "in the Uncompahgre, Gunnison, and Lake districts." In 1878 discoveries were made in the Quartz Creek district at the Silver Islet and Terrible mines, and at the Jimmy Mack mine south of Tincup. The years 1879 and 1880 witnessed the first rush of miners to southeastern Gunnison County, a large number of them coming from the Leadville district. They organized the towns of Pitkin and Ohio City early in 1879, and by the close of that year there were small villages at both places. It was not until 1880 that much work was done in the Tomichi district, and active development there did not begin until two years later. Most of the early prospectors departed, leaving a few who had faith in the discoveries to develop the mines. In 1882 a smelter was in operation at Virginia City, 2 miles north of Tincup, treating most of the ores of the Tincup and Quartz Creek districts. Later a small smelter was blown in at the forks of Tomichi Creek, 2½ miles south of White Pine, but met with little success. Both of these smelters have since been abandoned. By 1881 work in most of the camps was in full swing, and by 1883 the production of the districts was estimated by the Director of the Mint as follows: Tincup, $405,000; Tomichi, $400,000; Quartz Creek, including Gold Brick, $195,000. The statistics of the United States Geological Survey given in the annual volumes of "Mineral Resources," from 1903 to 1907, inclusive, show the production of the districts as follows:

Box Canyon: Gold, $1,351; silver, $35; most of this output being in 1906 and 1907.

Districts south of Tomichi Creek: Gold, $41,384; silver, $4,257. The mines of this district were most active in 1903 and 1906.

[a] Raymond, R. W., Statistics of mines and mining (eighth annual report), Washington, 1877, p. 284.

Gold Brick: Gold, $79,074; silver, $20,043; lead, $6,082. The years 1906 and 1907 show the most production, though this district has been a constant producer since 1903.

Quartz Creek: Silver, $97,115; gold, $4,600; zinc, $3,452. From 1903 to 1905 the mines of the district were fairly active. In 1906 production fell off, and none of the mines were producers in 1907.

Tincup: Silver, $30,198; gold, $15,757; lead, $6,132. Up to 1906 silver was the chief metal saved; in that year, however, probably owing to improvements in treatment, the gold values show a big increase.

Tomichi: Lead, $19,314; silver, $13,219; copper and zinc, $10,642; gold, $1,638. This has always been a silver and lead district, though in 1903 and 1905 small quantities of gold were recovered.

GENERAL OUTLINE.

In the early days of mining in southeastern Gunnison County only the deposits in the sedimentary areas appear to have been worked. These are, as a rule, replacements in the dolomitic beds. They have the usual irregular distribution of such deposits, but appear to be dependent on the amount of disturbance, which is due either to faulting or to intrusion of the formations. The major part of the deposits of this class have their chief value in silver, which is accompanied by galena, gray copper, and sphalerite, all of the ore being more or less altered to carbonates. As would be expected where intrusive porphyries cut sedimentary formations, there is much alteration at the contacts; and in one place at least a marked contact-metamorphic ore deposit was seen. The ore shows galena, sphalerite, and chalcopyrite in a gray crystalline limestone altered to epidote.

What prospecting has been done in the pre-Cambrian rocks shows that the general structure has a north-south direction, that the deposits occur as quartz veins following fractures, and that the values are chiefly in gold, with some silver, found in a mixture of gray copper, chalcopyrite, galena, and pyrite.

At one place in the Green Mountain district a gold-bearing quartz-tourmaline vein was found in a pegmatitic granite of probable pre-Cambrian age, and there is some evidence that the deposit also is of pre-Cambrian age. In contrast to this is the fact that a gold and silver bearing vein of relatively recent origin is found in the pre-Cambrian near an andesite flow. This deposit is a vein of quartz, calcite, and fluorite, showing strongly marked crustification. It carries its values in a combination of chalcopyrite, gray copper, galena, and sphalerite.

There are probably at least three distinct ages of ore formation, grouped as follows:

1. Pre-Cambrian, as represented by a quartz-tourmaline vein in pegmatitic granite and possibly other deposits in the same vicinity.

2. Post-Carboniferous, and probably post-Cretaceous, as represented by: (*a*) Replacement deposits in dolomite; (*b*) contact deposits; (*c*) vein deposits in

pre-Cambrian rocks following fault fissures. The deposits of the third class are closely related to intrusive porphyry.

3. Late Tertiary veins in pre-Cambrian rocks, showing crustification. These deposits appear to be connected with andesite flows.

DESCRIPTION OF DISTRICTS.

The mining districts of southeastern Gunnison County are, named from north to south, Cross Mountain, Tincup, Gold Brick, Quartz Creek, Gold Basin, Green Mountain, Cochetopa, Box Canyon, and Tomichi. In this report the detailed descriptions will be taken up in that order, except that the Gold Basin, Green Mountain, and Cochetopa districts will be discussed as one area, which, in fact, they are. The locations of mines and the boundaries of districts and sedimentary areas are shown on Plate I.

CROSS MOUNTAIN DISTRICT.

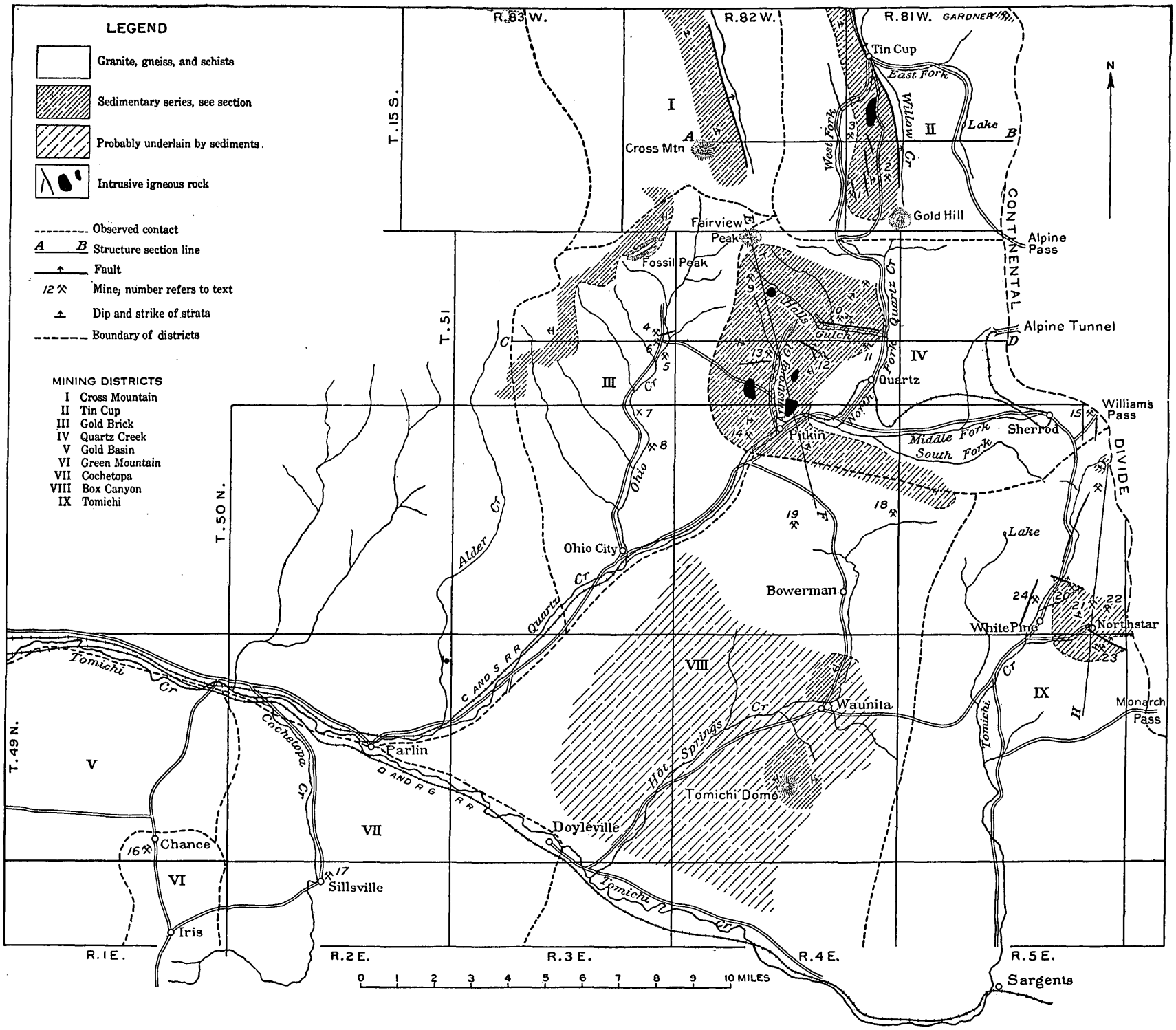
The mines of the Cross Mountain district lie principally on the east side of the ridge running northward from Fairview Peak beyond Cross Mountain, though there are some prospects east of Lottis Creek. The boundaries of the district are: To the south, the divide between Quartz Creek and Gunnison River, and to the east, the divide between Lottis and Willow creeks. The north and west boundaries are not known.

The eastern slope of the Fairview-Cross Mountain ridge is composed of the sedimentary beds, which dip eastward at relatively high angles and are cut off along Lottis Creek by a fault. The mines of this area were not visited; but it is stated that the ore is largely argentiferous galena, with its decomposition products. It is usually found in the dolomitic members of the section. East of this "lime belt" is an area about 3 miles in width, underlain by red granites and syenite and cut by a few porphyry dikes. In some places there are quartz veins, striking generally north and south, which carry values in gold, copper, and lead. Very few of these deposits have been opened by more than a 10-foot hole.

TINCUP DISTRICT.

Location and geology.—The Tincup district is bounded on the east by the Continental Divide, on the south by the Gunnison-Quartz Creek divide, and on the west by the Willow-Lottis Creek divide. To the north it now extends for at least 30 miles, the mines around Taylor Park and Italian Mountain being recorded in the Tincup mining district. Only the portion south of Tincup was visited by the writer.

The larger part of this area is underlain by pre-Cambrian gneiss and schist, though there are two areas of sedimentary formations,



SKETCH MAP OF SOUTHEASTERN GUNNISON COUNTY, COLO., SHOWING BOUNDARIES OF MINING DISTRICTS, DISTRIBUTION OF SEDIMENTARY AREAS, AND LOCATION OF MINES.

An area west of the west fork of Willow Creek, as well as the east wall of its valley, is made up of red granite of coarse texture. At the crest of the east side of the valley at its south end is an outcrop of the basal quartzite, which strikes N. 10° W. and cuts across the west fork southwest of Tincup. The rocks above the quartzite are as follows, in ascending order:

Gray limestone containing white chert.
"Parting" quartzite.
Gray dolomite.
Yellow shales and limestone.
Very dark dolomitic limestone.
Massive blue limestone.
Carbonaceous shales.

These beds dip 45° E. about 1½ miles south of Tincup, 70° E. just west of the town, and about 20° a little to the northeast near the top of the east-west divide, which cuts off the formations on the south.

Included in this sedimentary area, as well as in the older formations, are a number of dikes and sheets of fine to coarse grained acidic porphyry. The composition of the groundmass in the fine-grained variety is difficult to judge, but it is provisionally called felsitic porphyry. The coarser porphyry is granitic, containing orthoclase, quartz, and biotite crystals of megascopic size. On the ridge road running southward from Tincup to Pitkin the best exposures of the rocks are seen. In several places dikes and other small bodies of intrusive rocks, as well as two sheets, have been cut in grading. One sheet, about three-fourths of a mile south of town, is a coarse-grained acidic porphyry. Near the crest of the divide is another sheet which is much finer grained, though it appears to have the same general composition.

Near the top of the main range, at an altitude of 12,000 feet, is the second body of sediments. It is about 3 miles east-northeast of Tincup, on the north fork of the east fork of Willow Creek, and is composed of highly metamorphosed quartzite and limestone, all of which are much iron stained. These rocks are probably of pre-Cambrian age.

Mines.—The principal mines of this district lie to the south of Tincup, in the sedimentary area. The ore is a gold and silver bearing galena with some stephanite(?) and forms a replacement deposit in the more dolomitic members of the sedimentary series. The gangue minerals are largely quartz and calcite, though in many places the metallic minerals are found without other gangue than dolomite. The surface ores are said to have been very rich in free gold. These free-milling deposits were soon exhausted, argentiferous carbonates and silver chlorides being the principal ores of the oxidized zone. These in turn gave place to the galena, gray copper, and pyrites which

are being mined at present. Of late years more attention has been given to prospecting the gneiss and schist area north and east of the town. As a result of this work there have been some finds of lead-copper ores carrying gold. These ores are found in quartz-bearing veins which usually strike nearly north and south and fill small fault planes.

The only work that was being done in this district in July, 1908, was at the Blistered Horn tunnel, which starts into the east side of the west fork of Willow Creek about 3½ miles south of Tincup, to cut the workings of the Jimmy Mack property (1).[a] The shaft house of this mine is 1,500 feet above the mouth of the tunnel on the cropping of the ore. (See Pl. I.) The Blistered Horn tunnel starts in granite, but cuts the basal quartzite about 1,000 feet from the mouth. An upraise has been started to connect with the lower workings of the Mack. Entrance was not permitted, owing to the absence of the superintendent, the information given above being obtained from him after the field work was finished.

The Gold Cup, Tincup, and Drew mines (2) are all situated close together on the north slope of Gold Hill, about 3 miles due south of Tincup. All these workings were inaccessible on account of the bad air and accumulations of ice. So far as could be seen from the surface, the inclines follow the ore and dip about 30° to 35° ENE. The extent of underground working is not known. The ore seen on the dump is largely galena, with some pyrite and chalcopyrite, stained with lead and copper carbonates. From the rock on the dumps, together with that in the ore bin, it is judged that the deposits are largely in the dolomite, which lies immediately below the massive blue limestone. This fact, however, could not be verified by actual observation. The owners of the Gold Cup property have started a tunnel from the middle fork of Willow Creek to intersect their ore. This tunnel was over 800 feet in length, the first 100 feet cutting carbonaceous shales and the breast being in the massive blue limestone.

There are two mills in this district, both of which are on the west fork of Willow Creek. One, a concentrating plant, is at the Blistered Horn tunnel, and the other, a 90-ton cyanide mill, is below the West Gold Hill mine (3), about 2 miles southwest of Tincup.

GOLD BRICK DISTRICT.

Location and geology.—The Gold Brick district lies entirely within the Ohio Creek drainage area (see Pl. I), the rim of the basin forming its boundaries. The shipping and supply point is Ohio City, whence a good wagon road runs up Ohio Creek to the mines. The

[a] Numbers after names of mines correspond to those used on Plate I.

entire area is in pre-Cambrian rocks. Red granites are exposed about Ohio City, but these give place to gneiss and schists about 3 miles north of the town. There are schists of various kinds, ranging from dark hornblendic varieties to those made up of light muscovite and quartz. The schistosity strikes N. 5° W., as do most of the faults and dikes.

The ore deposits are found in veins which range in width from a fraction of an inch to 4 feet, and which without noted exception parallel the dip and strike of the general structure of the schists and seem to follow zones of movement. The smaller veins contain gold and silver bearing lead, copper, zinc, and iron sulphides, with a very small amount of quartz and clay gangue. Many of the larger veins are filled with clay gouge, in which there are bodies of metallic minerals usually accompanied by granular quartz.

Mines.—At only two of the mines of this district was work in progress at the time of the writer's visit—the Sandy Hook tunnel and the Gold Links tunnel. The dump of the Cortland mine was, however, being milled at a plant located on Quartz Creek about a mile northeast of Ohio City.

The Sandy Hook tunnel (4) is driven into the west wall of Ohio Creek about 8½ miles north of Ohio City. The country rocks are schist and gneiss, intensely fractured in a north-south direction. About 200 feet south of the tunnel there is a 300-foot dike of coarse-grained granite porphyry which cuts across the valley in an east-west direction. The tunnel was 480 feet in length and was driven due west. In this distance two small veins of lead-zinc ore had been cut, and the breast was in a 2-foot seam of clay gouge that showed some galena and pyrite. The veins strike N. 5° W. and follow the schistosity, which coincides with the direction of the faults; it was noticed, however, that the veins widen somewhat and become richer to the south, near the intrusive. The ore is said to carry gold and silver. The metallic minerals are galena, sphalerite, and pyrite in a quartz gangue. A steam-driven air compressor supplies two air drills, and it was the intention of the owners to install a concentrating plant on the property at an early date.

The Gold Links tunnel (5) is driven 3,500 feet into the east wall of Ohio Creek about 7¾ miles north of Ohio City, just below a small branch of the stream which comes in from the east. The country rock is schist and granite. The tunnel cuts through dark schists for the most part, though it encountered two small bodies of granite and one dike of fine-grained white acidic porphyry which contained iron pyrites. The whole body of rock is intensely fractured in a north-south direction and many, though not all, of the faults are filled with ore. Six workable veins have been cut in the tunnel. These range from a few inches up to several feet in width. The smaller

veins seem to be the richer and are filled almost entirely with galena, chalcopyrite, pyrites, and sphalerite in a fine quartz gangue. At one place in the tunnel a body of schist 20 feet wide contains, according to reports, enough sulphides to work as low-grade ore.

The company has two steam plants, one running compressors for the air drills and the other the concentrating mill. The mill is new, only 20 of the 50 stamps being in position. It was hoped, however, that all the machinery would be in place by the end of the summer. After the ore is sorted into smelting and concentrating grades at the top of the building the concentrating ore goes into storage bins on being rough broken by hand. There is a set of rolls for each battery of 10 stamps, the pulp from which passes over 12 feet of plate before it is conveyed to the eight Wilfley tables on the main floor of the mill. Most of the gold is saved on the plates, though the concentrates are said to contain some gold values as well as silver.

Other mines of the district which were closed down in July, 1908, are the Belzora Bassic tunnel (6), one-fourth of a mile south of the Sandy Hook tunnel, and the Carter tunnel (7) and Raymond Consolidated tunnel (8), both on Ohio Creek, south of the Gold Links. The Raymond Consolidated is the nearest to Ohio City. (See Pl. I.) At all these properties air is used for drilling, and at the Raymond and Carter there are small concentrating plants.

QUARTZ CREEK DISTRICT.

Location and geology.—The Quartz Creek mining district is bounded on the north by the ridge between Fairview Peak and the Continental Divide, on the east by the main range, on the south by Quartz Creek, and on the west by the divide between Armstrong Gulch and Ohio Creek. (See Pl. I.)

The general geology is shown on Plate I and figure 1. The Armstrong Gulch area is underlain by the sedimentary series described in detail on pages 24–25. East of the north fork of Quartz Creek pre-Cambrian gneiss and granite are exposed to the top of the main range. The mines of the district are, with a few exceptions, located in the "lime belt" exposed in Armstrong and Hall gulches; there are, however, some mines about 2 miles west of Sherrod, near the crest of the Continental Divide. The deposits within the sedimentary formations are replacements in the dolomitic beds; those near Sherrod are of recent origin and lie wholly within the pre-Cambrian rocks.

The sedimentary beds of the Pitkin region dip toward Armstrong Gulch from all directions, the basal quartzite being everywhere exposed on the outer rim. The dip varies from 30° around the edge of the area to 5° to 13° in the central portion. Ore is usually found in

the dolomite which lies just below the "Fairview" shale, but is sometimes, though very rarely, encountered in the two upper dolomites—that just above the "buckskin" limestone and the dolomitic portion of the upper massive blue limestone. The croppings of the "Fairview" shale around this area have afforded the best opportunity for prospecting, and as a consequence most of the mines are located near the circumference of the basin. The exceptions are at points numbered 12 and 13 on Plate I. At 12 there is a small fault striking N. 60° W., which runs out into a low fold before it reaches Armstrong Gulch, and along which there has been some mineralization. At 13 a shaft was sunk through the undisturbed overlying formations in the hope of finding ore at the "Fairview" contact.

Mines.—At none of the mines of this district was work being done in July, 1908, except at the Red Jacket. Most of the mines have been closed for some time, and accumulations of water or ice, together with bad air, rendered access to them impossible.

The ore at all the mines is largely argentiferous galena, with possibly some stephanite, and gray copper. Wherever seen it is more or less stained with lead and copper carbonates. In some of the ore from the Fairview mine (9) kernels of crystallized galena were seen surrounded by a very fine grained dark mineral showing no crystal form, which reacts like galena but contains a large percentage of silver; this in turn is in many places surrounded by lead and copper carbonates. The ore bodies are very irregular and lie usually in the upper portion of the dolomite just under the yellow "Fairview" shale. They are often vuggy, exhibiting crystals of calcite and quartz on the drusy surfaces. The gangue is largely calcite and quartz, though numerous masses of ore have no other gangue than the dolomite.

The Fairview mine is 7½ miles a little west of north of Pitkin, on the divide between Armstrong and Hall gulches about 1½ miles southeast of Fairview Peak. It was worked by an incline said to be 800 feet deep, with levels every 100 feet. This incline dips 35° S., following the ore immediately under the "Fairview" shale. The first level is 70 feet below the surface. Most of the ore has been removed from it by overhead stoping, being sorted as mined, and the barren rock being used as filling. The mine has been closed for some years, and the incline below the first level is half full of ice, which made further exploration impracticable. All the machinery except the boiler has been removed, and the buildings are going to ruin very rapidly.

The Cleopatra lies just east of the Fairview on the same contact. The upper workings have been abandoned, however, as the company has a tunnel in Hall Gulch about 2,000 feet below the cropping. This

tunnel could not be entered. Ore has been taken out through it, however, and some is still to be seen in bins and sacks at the entrance.

The Swiss Bell mine (10) is on the north side of Hall Gulch, about 2 miles from Quartz Creek. The ore here lies directly on the surface, in the dolomite in the upper portion of the massive blue limestone, where the beds are locally folded into a low anticline. The ore is very irregular in distribution, and as the old workings have followed it they are rather complicated; they consist of an incline and shaft which reach a depth of 100 feet. A new shaft about 500 feet north of these old workings has been sunk to a considerable depth, but no ore has been taken out of it. Water was standing well up in this shaft, so its depth could not be ascertained. It has two compartments and the rock was raised by steam hoist.

The Silent Friend (11) and Terrible (12) mines were not visited, as the workings were inaccessible. They are both worked by inclines, that of the former dipping to the west and that of the latter to the northwest on a fault.

The Silver Basin shaft (13) is said to be about 750 feet deep, having cut the "Fairview" contact. Whether ore was found is not certain. The statements of the mining men of the vicinity differ and the writer could not make a personal inspection, as the shaft is full of water.

The Red Jacket property (14) lies about three-fourths of a mile west of Pitkin and is opened by a shaft and tunnel. The shaft was full of water, but work in the tunnel was in progress on the "Fairview" contact. No large bodies of ore were visible, though there were some small pockets of galena exposed in the workings.

It seems to be the opinion of most of the prospectors at Pitkin that ore will always be found at the contact of the dolomite and the "Fairview" shale. This opinion, however, is not substantiated in all cases. One in particular came under the writer's notice. A tunnel driven into the east side of Armstrong Gulch to intersect the workings of the Terrible mine started near the bottom of the massive blue limestone and has cut all the formations, including the lowest (Silurian) limestone, which here dips about 13° SW., without finding any indications of mineralization.

REGION EAST OF SHERROD.

About 2 miles east of Sherrod siding, on the Colorado and Southern Railway, there is a group of mines situated on a small spur of the Continental Divide. The rock of the area is pre-Cambrian gneiss, capped at the top of the range by a dark-red, fine-grained rock, probably andesite, that is cut in at least one place by an acidic porphyry dike, which strikes north and south. The ore from these mines is a silver and gold bearing lead, zinc, and copper sulphide

found in veins containing quartz, calcite, and fluorite. The veins strike a little east of north, show marked banded structure due to deposition, and are probably the most recent deposits in the region described in this report.

The N. B. C. mine (15) is on the north side of the spur about 2 miles by road from Sherrod. It is opened by a tunnel, which was 180 feet long at the time of visit. The vein for which the operators were driving had not been cut, but they hoped it would be found within the next 50 feet. The croppings of the vein above the workings stand out fairly well but do not show much mineralization other than quartz, calcite, and fluorite having a distinctly banded structure.

The Brittle Silver mine is on the west slope of the ridge, about half a mile north of the N. B. C. workings. It has not been in operation of late and as no one with authority was on the ground it could not be examined.

DISTRICTS SOUTH OF TOMICHI CREEK.

There are two districts south of Tomichi Creek, the Gold Basin and Cochetopa, within which a small area around Iris and Chance has been set aside as a separate mining district called Green Mountain. The rocks of this area are entirely red and gray granite and gneiss. Within this main body are what appear to be segregations of the ferromagnesian minerals, many of which closely resemble dikes in form. The granite is usually coarse textured and in some places is rather pegmatitic.

Most of the mines are situated about the towns of Iris and Chance, but there are a few near Sillsville. Nearly all these mines are abandoned, the only one in all this area that was open at the time of visit being the Lucky Strike mine (16), south of Chance. This mine is opened by two shafts, one equipped with a steam hoist and the other with a whim. The main shaft has only one compartment and is about 200 feet deep, with the first level 80 feet below the collar. Most of the ore has been stoped out above this drift, though at present ore is being taken from approximately the same level at the second shaft, 600 feet farther northwest. The ore found in a vein 2 to 4 feet in width, which strikes north of east and dips to the southwest, consists of massive iron-stained to white quartz containing tourmaline. The inclosing rock is gneissoid and locally shows good walls, though in many places the dividing line between ore and barren rock can not be determined. A segregation of orthoclase feldspar crystals, resembling a vein striking parallel with the ore body, is exposed about 300 feet northeast of the vein and can be traced by its outcrops for a considerable distance. A crusher and 5-stamp mill, situated just north of the main shaft, reduce the ore, the values being saved

on an 8-foot amalgamation plate. The tenor of the ores is reported by the operators to be from 1 to 2 ounces per ton, of which 90 per cent is saved. The waste pulp contains a small amount of copper and possibly a little tellurium.

The Maple Leaf mine (17), near Sillsville, was closed in the latter part of July, 1908, so that access to the works could not be obtained. The ore is said to be a free-milling massive quartz containing both gold and silver, found in veins in a coarse dioritic rock. The veins strike almost east and west.

BOX CANYON DISTRICT.

The Box Canyon district is bounded on the north by Quartz Creek, on the south by Tomichi Creek, and on the east by the divide between Tomichi and Hot Spring creeks. The southwestern portion of this area is probably underlain by the sedimentary formations which are exposed on the flanks of Tomichi Dome and north of Wanita. In the area north of Bowerman are exposed mica schists having a general northwest-southeast strike, included in which are lenses of diorite paralleling the schists. The mines of the district are north of Bowerman, the usual ore being a free-milling quartz, though it is said that a copper deposit has been found at the Abe Lincoln tunnel, just north of the town.

The Independence mine (18) is 3½ miles southeast of Pitkin and about the same distance northeast of Bowerman. It has been abandoned for several years, as the deposit was entirely exhausted. The ore body was a lens of mica schist seamed and veined with quartz containing free gold. The deposit was worked by a shaft which ran out of the ore at a depth of about 80 feet. Two tunnels were driven in below the shaft, and though quartz stringers were found no values could be obtained.

The Camp Bird mine (19) is 1½ miles northwest of Bowerman. The ore is a free-milling quartz, somewhat iron-stained and honeycombed, found at the contact of lenses of diorite and mica schist. The two-compartment shaft is said to be more than 100 feet deep. A bucket hoist is used to raise the ore, which is sorted at the mine and transported by wagon to a 10-stamp mill below Bowerman.

TOMICHI DISTRICT.

Location and geology.—The Tomichi mining district is bounded on the west by the divide between Tomichi and Hot Spring creeks, on the north by the divide between Tomichi and Quartz creeks, and on the east by the main Sawatch Range. White Pine, the only town in the district, is nearly deserted, as very little in the way of mining operations is being done. The southern and western parts of the district are largely occupied by red granite. North of the forks of Tomichi

Creek gray granite and gneiss are found to the top of the Continental Divide, except for the two small areas of sedimentary beds shown in section H–G, figure 1, and on Plate I. These beds are very much altered and little could be determined as to their correlation with the sections at Pitkin and Tincup. The general structure of the granitoid rocks trends north and south and is marked by many faults, seen in the underground workings, and by several dikes of quartz-bearing porphyry. There are, however, two marked faults just east of White Pine, striking northwest and southeast, that determine the form of the small sedimentary area where the principal mines were located.

Mines.—The Parole tunnel and Spar Copper shaft (20) are situated about half a mile northeast of White Pine; the former is about 900 feet below the latter and starts about 900 feet west of it. The shaft is just north of the limestone-granite contact on a group of veinlets which are cut in the tunnel about 900 feet from its mouth. This tunnel starts in limestone, but cuts the contact about 800 feet from the mouth, running through barren gray granite for 100 feet to the veins. The ore is largely gray copper and chalcopyrite, though some galena is seen in veins which strike approximately north and south. The chief values are in gold and silver.

The Silver Trowel tunnel (21) lies about 1¼ miles east of White Pine, on Galena Creek, a little west of the center of the sedimentary area. The beds dip from 30° to 45° N. and strike a little north of east. The tunnel is about 120 feet long and cuts near the mouth a dike of granite porphyry which strikes N. 10° W. Beyond the dike is a gray crystalline limestone resembling marble, which has been altered to almost pure epidote near the dike. Ore is found in the altered portion next to the unaltered limestone; it consists of galena, sphalerite, and some chalcopyrite, and carries silver and gold.

The Eureka incline (22), located about three-fourths of a mile southeast of the tunnel last described, follows the contact between quartzite and blue limestone, which dips to the north at 20° to 45°. It is about 400 feet deep, with 100-foot levels. The surface ore was largely lead carbonate, which gave way to galena with depth, and had almost no zinc. It is a typical replacement deposit at the juncture of limestone and quartzite.

The Morning Star mine (23) is just south of the small fault shown on Plate I. This fault cuts the sedimentary area, giving a granite hanging wall and a limestone foot wall for the ore, which is a combination of lead and zinc sulphide.

West of White Pine the ridge between the two forks of Tomichi Creek is composed of gray granite severely faulted along lines striking a few degrees east of north and intruded by dikes of granite porphyry that parallel the faults. There are several mines along the line of most intense disturbance, about one-half mile west of town, at

which the ore is said to consist of copper and lead sulphides carrying gold and silver. The ore occurs in veins that fill fault planes. The chief mines here are the Silver Cord, Lily, and Alice. The Alwilda tunnel (24) one-fourth of a mile north of White Pine, crosscuts the granite and opens the extension of the Silver Cord vein, which is here about 10 inches wide and contains gray copper, chalcopyrite, and galena in a quartz gangue.

On Tomichi Creek there are two small deposits of iron, both located north of White Pine, one half a mile and the other 1½ miles up the creek. The latter is a flat-lying body from 1 to 1½ feet thick, occupying a flat above an old beaver dam. The former deposit is exposed by an open cut and tunnel about 200 feet above the bottom of the valley on the east wall at the fault contact of the larger sedimentary area and the granite. Here there are two belts of magnetite separated by about 50 feet of altered limestone. The northern body lies against gray granite. It is 50 feet wide and not so rich as the southern one, which is 15 feet wide and lies on top of an unaltered gray limestone. This limestone contains white chert, which greatly resembles the Silurian(?) limestone of the Pitkin area. A small amount of this ore was mined for use as flux at the old smelter, 5 miles down the creek. Since that smelter has been out of use nothing has been done with the deposit, as it is too small to pay for the heavy transportation charges.

THE HORNSILVER DISTRICT, NEVADA.

By FREDERICK LESLIE RANSOME.

The town of Hornsilver, which came into existence in 1907, lies in Esmeralda County, Nev., 26 miles south-southwest of Goldfield, 14 miles southwest of Cuprite (a station on the Las Vegas and Tonopah and the Tonopah and Tidewater railroads), and 12 miles southeast of Lida. Mining in this vicinity is not wholly recent, and an earlier settlement on the site of Hornsilver was known as Lime Point. Prospecting in this region began about 1868, and over twenty years ago ore was hauled to a mill near Lida from the Grand Central and other claims near Lime Point; but most of these claims had long been abandoned when the growth of Tonopah and Goldfield called attention anew to this part of Nevada and provided better facilities than formerly existed for its economic development. Work on the Great Western vein began in 1905, and the Grand Central was relocated early in 1908, after the presence of rich ore in the Great Western had been established.

The following notes are based on a visit of a day's duration in June, 1908. At that time there were about 500 people in the district and considerable prospecting by lessees was in progress in the hills west and south of the town. Water was hauled from a spring 12 miles away and supplies were brought from Goldfield by wagons or partly by rail by way of Cuprite. One mine only, the Great Western, was shipping ore.

Hornsilver, at an altitude of 5,900 feet, lies on a gentle alluvial slope, which opens northward into one of the broad desert valleys common in the region and is inclosed on other sides by hills rising from 500 to 1,000 feet above the town.

The rocks of the district are limestones and calcareous shales, which are intruded and in places more or less metamorphosed by masses of granite. The stratified rocks are mapped by S. H. Ball[a] on his reconnaissance map as the Prospect Mountain limestone,[b] of Cambrian age. He described briefly[c] the rocks of Slate Ridge, south of the

[a] A geologic reconnaissance in southwestern Nevada and eastern California: Bull. U. S. Geol. Survey No. 308, 1907, Pl. I.

[b] Now known as the Eldorado limestone.

[c] Op. cit., pp. 182–195.

new town, and shows that these old stratified rocks are continuous with the more metamorphosed beds at Tokop and Gold Mountain, southeast of that ridge.

Near Hornsilver some shale is interbedded with the limestone, but a considerable thickness of shale with subordinate calcareous beds underlies fairly massive limestone, which is exposed in the hills south and east of town. The ores lie mainly in these shales.

The principal veins are southwest of town, within a distance of a mile. They constitute an approximately parallel system and cut across the bedding of the shales with a prevailing strike of N. 55° to 60° W. and with steep dips. Although the wall rock is generally shale, the veins are parallel to some fine-grained and rather obscurely exposed dioritic dikes. The two principal veins are the Great Western and Grand Central, which are about a quarter of a mile apart, the Grand Central being the farther from town. These have been traced by trenches and pits for distances of 3,000 to 4,000 feet along their not very conspicuous outcrops. There are also three or four other veins on which less work has been done.

All of the vein material that could be seen in 1908 was thoroughly oxidized and for the most part soft. The fissures after being filled with quartz and sulphides evidently had been crushed by later movement along the original dislocation and the vein was thereby rendered specially permeable to oxidizing solutions. The valuable constituents of the deposits are native gold and chloride of silver.

The Great Western mine at the time of visit was developed to a depth of 200 feet and equipped with a 15-horsepower gasoline hoist. The 100-foot level was about 600 feet long and the 200-foot level about 175 feet long. Since that time a 300-foot level has been opened. The gross product of the mine in June, 1908, was, according to the owners, between $30,000 and $40,000, the shipments ranging in assay value from $75 to $400 a ton.

The Great Western vein strikes N. 60° W. and near the shaft dips 50° NE. At the northwest end of the 100-foot level, however, the vein is nearly vertical. There is a very regular and persistent hanging wall with a thin skin of soft gouge separating ore from country rock. The vein is in some places about 20 feet wide and consists of the usual crushed rusty quartz found in the veins of this district. Much of this material is said to yield assays of about $30 a ton, but only the higher-grade portions have been stoped. The ore from these portions shows abundant cerargyrite as sparkling olive-green crusts on the rusty quartz fragments and as small crystals in spongy limonitic material residual from the oxidation of the original sulphides. Minute quantities of a bluish-green mineral in thin crystalline rosettes associated with the cerargyrite are probably embolite or bromyrite but have not been chemically tested. The ore shipped in 1908 con-

tained relatively little gold—not more than 15 per cent of the total value of the precious metals present. Recent reports, however, indicate that ore with a much higher proportion of gold has been stoped in the northwestern part of the 200-foot level.

A second vein has been cut near the shaft on the 100-foot level, samples from which were said to contain more gold than silver. It had not been stoped at the time of visit. In January, 1909, the mine was reported to be shipping 12 tons of ore a day by way of Cuprite.

A short distance southeast of the Great Western mine the vein passes under alluvial material and little is known of its extent or value in that direction. It has been traced northwestward, however, for 3,000 feet or more and several sets of lessees were engaged in 1908 in exploring this vein or others in the same general zone of fissuring.

No work was in progress on the Grand Central vein in June, 1908, although some shipments have since been reported in the mining press.

About 1½ miles due south of Hornsilver, on the other side of the limestone ridge (Slate Ridge), which separates the town from a small arm of Death Valley, known as Oriental Wash, is the Redemption mine, worked superficially many years ago and recently reopened by lessees. There are two adjacent parallel veins in limestone, striking about N. 40° E. and standing nearly vertical. These veins are opened by small tunnels and shallow winzes. The ore is partly oxidized galena and contains massicot, cerusite, wulfenite, and probably some cerargyrite. The greatest width of ore observed is 1 foot. The lessees, who were concentrating this material by hand jigging, stated that the best of the concentrates carry 40 per cent of lead, 30 per cent of zinc, and 40 ounces of silver to the ton. No zinc minerals were observed in the ore, much of which is soft and earthy.

ROUND MOUNTAIN, NEVADA.

By FREDERICK LESLIE RANSOME.

A few hours were spent at Round Mountain, Nev., on June 29, 1908, and the following notes are based upon the necessarily hasty examination possible in so short a visit. The town of Round Mountain, which contains from 500 to 600 people, is in Nye County, 45 miles (about 70 miles by road) north of Tonopah and nearly the same distance south of Austin. It lies on the east side of Big Smoky Valley at the base of the Toquima Range, being 12 miles north of Manhattan and 3 miles southwest of the abandoned mining camp of Jefferson. Further details regarding the surroundings of the district may be had from the Tonopah topographic sheet of the Geological Survey, and a good general description of the camp has been published by George A. Packard.[a]

The town takes its name from a small oval hill of rhyolite which rises about 400 feet above the alluvial slope of the valley's edge. There is abundant water for all ordinary purposes, a supply from Shoshone Creek, east of town, having been made available by an outlay of $65,000.

The rhyolite of Round Mountain is generally fresh, with abundant phenocrysts of quartz and feldspar, up to about 5 millimeters in diameter, in a light-gray lithoidal matrix, which, as a rule, shows some flow structure. No microscopical study has been made of this rock, but it appears to be a normal rhyolite with orthoclase (sanidine) as the principal feldspar. According to Mr. Packard, granite has been found underlying the rhyolite near the saddle connecting Round Mountain with the main range east of it, and some shafts east and northeast of the hill are said to show slate and quartzite.

The only mine examined during my visit was the Sunnyside, on the south slope of Round Mountain. This, the principal mine of the district, is worked through a 35° shaft to a depth of 550 feet, measured on the incline. The levels are 50 feet apart and explore the vein for a length of about 300 feet. Although the general strike of the vein is nearly east and west, the levels, which are driven on the ore, all show sharp curvature, as illustrated in figure 2, so that the strike

[a] Round Mountain, Nevada: Min. and Sci. Press, June 13, 1908, pp. 807–809.

of the deposit at different places may vary by as much as 90°. The ore body is fully 300 feet long and from 6 to 20 feet in width as measured in horizontal planes and extends from the surface to an unknown distance below the bottom level. The dip varies from 35° N. at the surface to 20° N. on the 550-foot level.

The ore is all oxidized and carries, on an average, from $10 to $15 in gold to the ton. Ore worth $25 a ton is exceptionally good. Although the deposit has been referred to as a vein, it is not really of that class. It is a mass of jointed and irregularly cracked rhyolite, somewhat stained with iron oxide, but showing no conspicuous alteration and no evidence of extensive movement. In most places the ore is separated from the country rock of the hanging wall by a close fissure or joint, the difference between ore and waste being not, as a rule, evident to the eye. Such a joint, when followed along the strike, is found to pass at some point into the ore or into the country rock, and another one of slightly different strike takes its place as a working boundary to the ore. The hanging wall is thus defined by a series

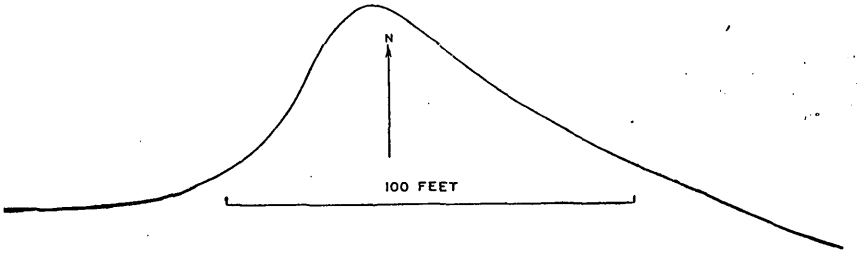


FIGURE 2.—General plan of a level in the Sunnyside mine, Round Mountain, Nev., showing the curved strike of the deposit.

of joints that intersect or meet at large angles. The distinction between ore and country rock is less definite on the foot-wall side of the deposit. On the whole, the limits of the ore body must be determined by panning or assaying and are not certainly recognizable from structure or appearance.

The value of the ore is practically all in gold, which is readily amalgamated. The mill, equipped with two Nissen stamps, two Huntington mills, and a tube mill, treats about 100 tons a day and extracts 92 per cent of the gold. Some coarse gold is found, associated with limonite in crevices in the rhyolite, but in most of the ore none of the metal is visible. No pyrite was seen in any of the ore, although a little was noted disseminated in the rhyolite at one place on one of the lower levels. In 1908 the mine, according to Mr. J. P. Loftus, president of the company, was producing from $35,000 to $42,000 a month. Steam power is used. The fuel is wood from the Toquima National Forest, purchased at $1.25 a cord and cut and delivered at a total cost of $8 to $10 a cord.

A few hundred yards west of the Sunnyside mine some lessees have a shaft 200 feet deep on what is probably a continuation of the same deposit. At the time of visit they were hoisting $15 ore, which was hauled to a mill near town and there treated at a total cost of $7 a ton.

West of this lease, near the west end of the hill, is the Sphinx mine, 200 feet deep, and probably also on the same zone of mineralization. The ore at the time of visit was similar to that of the Sunnyside mine but of lower grade, the average value being a little less than $10 a ton. About 25 tons a day are treated in a Huntington milling plant with no stamps.

The Fairview and Daisy mines, east of Round Mountain, were producing in 1908, but were not visited. Their ore is said to lie in rhyolite and to be similar in general character to that of the Sunnyside. The Fairview has a 20-ton mill on Shoshone Creek, a mile northeast of town.

A notable feature of the south slope of Round Mountain is the wide distribution of the gold. Along the whole south base of the hill the superficial detritus or wash carries gold. This material, which consists of angular fragments of rhyolite of all sizes up to a few feet in diameter, with more or less earth and sand, has a maximum thickness of about 10 feet. It shows only traces of rough stratification and has accumulated by general creep down the slope accelerated by occasional heavy rains. At the base of the hill the deposit thickens and merges with the general wash of Great Smoky Valley. Hydraulic operations are confined to the hill, where the bed rock is within reach and where there is sufficient fall for sluicing. The gold is distributed through the deposit from top to bottom. When the rhyolitic bed rock is exposed it is found to be covered in many places with a firm crust of buff-colored calcium carbonate up to an inch in thickness. This adheres strongly to the fresh surface of the rhyolite as a rough, travertine-like crust and in places carries enough gold to make its removal by blasting profitable, especially as considerable gold is carried also in the superficial cracks of the rhyolite.

Two monitors were playing in June, 1908, and the washing, according to Mr. Loftus, was yielding about $20,000 a month. The water, however, was getting rather low and it was not possible to keep both streams in continuous operation. Prior to the use of water, gold to the value of $39,128 was obtained with two dry-washing machines. The ground worked by this method is said to have averaged over $5 a yard.[a] The gold is generally rather fine, but some nuggets of fair size have been found.

A large part of the rhyolite on the south side of Round Mountain, both under the wash and higher up the slope, contains considerable

[a] Packard, G. A., op. cit., p. 809.

gold, partly in visible joints or small fissures, and partly in rock which is not noticeably fractured. Where the joints are close together and the rhyolite between them rather soft and decomposed, assays as high as $250 to the ton are said to have been obtained from samples taken near the surface; and from solid blocks of unfissured rhyolite assays up to $4 a ton are reported. How far this gold represents mere superficial enrichment is still an unsolved problem. In 1908 prospecting was in progress to determine whether or not extensive masses of rhyolite on the south side of the hill can be worked by an open-cut method for the gold scattered through the rock.

MINERAL RESOURCES OF THE GRANTS PASS QUADRANGLE AND BORDERING DISTRICTS, OREGON.

By J. S. Diller and G. F. Kay.

GEOGRAPHY AND GEOLOGY.

By J. S. Diller.

INTRODUCTION.

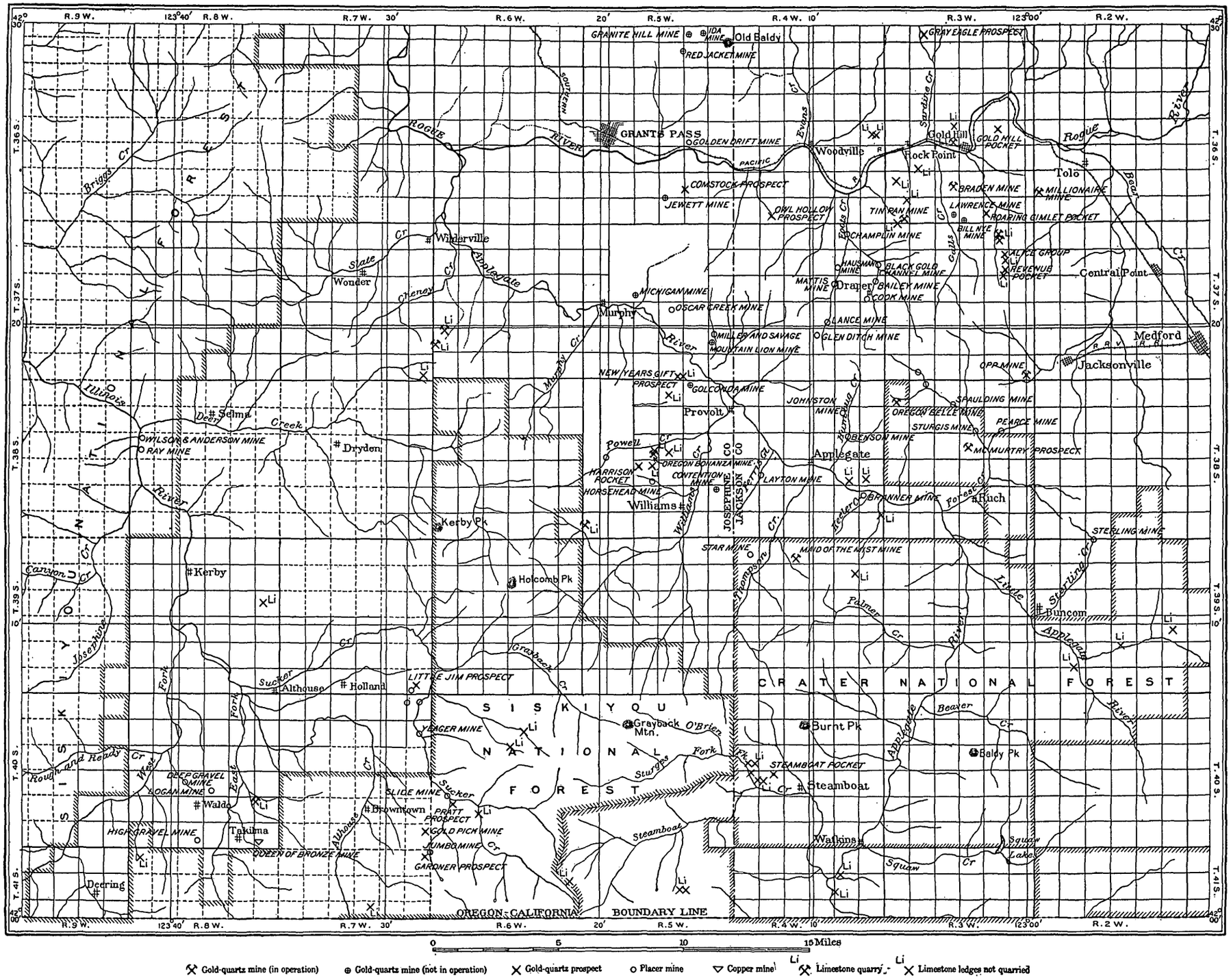
The region considered in this paper is in southwestern Oregon. As shown on the accompanying map (Pl. II), it extends from the neighborhood of Grants Pass on the north to the State line on the south, and from Illinois River on the west nearly to Jacksonville on the east. It is mainly the country drained by Applegate River, and may be conveniently referred to as the Applegate region. It has an area of approximately 1,000 square miles.

Although the principal line of travel across the area had been previously examined, by far the greater part of the work, on which this paper was based, was done in the summer of 1908. I studied the general geology, assisted by James Storrs, who searched for fossils, and Prof. G. F. Kay examined the mines which he describes in the second part of this report.

For the Grants Pass quadrangle we had a good topographic map on the scale of about 2 miles to an inch, but for the border land on the east, west, and south the available maps were on a much smaller scale. On account of the large size of the area to be covered and its complicated structure it was not possible to examine the region in sufficient detail for final mapping.

GEOGRAPHY.

The Siskiyou Mountains of southwestern Oregon and the Salmon, Trinity, South Fork, and North Yolla Bolly Mountains of northwestern California all belong to the same group, to which some years ago the late Maj. J. W. Powell, then Director of the United States Geological Survey, gave the name Klamath Mountains. This is not only a very convenient but an appropriate term and is coming into general use. The Klamath Mountains lie at the meeting point of the



Gold-quartz mine (in operation) ⊕ Gold-quartz mine (not in operation) × Gold-quartz prospect ○ Placer mine ▽ Copper mine ⚒ Limestone quarry Li × Limestone ledges not quarried

MAP SHOWING LIMESTONES, GOLD-QUARTZ MINES, AND PROSPECTS OF GRANTS PASS QUADRANGLE AND BORDERING DISTRICTS, OREGON.

Sierra Nevada, the Cascade Range, and the Coast Range. They are most closely related in position and structure to the Coast Range, but the kinds of rocks of which they are made up are like those of the Sierra Nevada.

The region under consideration lies within the Klamath Mountain group and extends from the crest of the Siskiyou Mountains northward to Rogue River, where the stage road and the Southern Pacific Railroad afford a convenient outlet for transportation. Applegate River, which heads in the Siskiyou Mountains, has carved out an irregular but in many places broad and fertile valley across the region. A stage mail route follows the Applegate to the crest of the Siskiyou Mountains in California, but there is no outlet to the south.

The region is mountainous and ranges in altitude from about 871 feet to over 7,043 feet above the sea. The fertile valleys are farmed and the mountains are generally well forested, especially in the southeastern portion, which belongs to the Siskiyou National Forest.

GEOLOGY.

GENERAL OUTLINE.

The rocks of the Applegate region include both sedimentary and igneous rocks of various types and ages. They are arranged in irregular elongated patches or bands running northeast and southwest diagonally across the Grant Pass quadrangle, and the igneous rocks occupy by far the larger portion of the area.

The sedimentary rocks are mainly Paleozoic (Devonian, probably with some Carboniferous), though there are a few of Tertiary age and some of Cretaceous. Besides these there is a mass of mica schists near the crest of the Siskiyou Mountains that appears to be older than the Paleozoic rocks of the same region.

The igneous rocks are in part intrusive, but many of them, possibly the greater portion, are volcanic.

MICA SCHIST.

Mica schist appears to be among the oldest rocks of this portion of Oregon. It occurs in a large area about Squaw Lake, in the southeast corner of the Grants Pass quadrangle, where it is associated with hornblende and chlorite schists. The last two are probably derived from the alteration of ancient igneous rocks, but the origin and age of the mica schist here referred to are not definitely known. Its nearness to the large mass of granodiorite that forms the core of the Siskiyou Range suggests that it may be due to the contact metamorphism of Paleozoic sediments by the granodiorite. However, the absence of andalusite and other characteristic contact minerals favors the view that the mica schist is older than the Paleo-

zoic rocks of that region and lies unconformably beneath them. It is typical mica schist for the most part, with numerous leaves and veins of quartz and locally considerable pyrite.

PALEOZOIC ROCKS.

Kinds of rocks.—The Paleozoic sediments consist of clay slates, dark, siliceous, locally banded slates, and greenish slates, interbedded with tuffs and lentils of limestone. Near the contact with granodiorite they are locally metamorphosed into fine-grained mica schist, which usually contains characteristic minerals, such as chiastolite and staurolite.

Distribution of limestone.—Limestone is one of the most important Paleozoic sedimentary rocks of the region from an economic point of view, especially on account of its relation to the cement industry, and more of it occurs in the Grants Pass quadrangle than in any other quadrangle of equal size in western Oregon.

Measured directly across the strike the area occupied mainly by Paleozoic rocks, both sedimentary and igneous, in the Applegate region has a width of nearly 30 miles, in which there are four more or less clearly defined belts of limestone containing about 50 masses, most of which are located on the accompanying map as quarries or prospects. The largest outcrop is not over one-third of a mile in length and 200 feet in thickness.

The first belt of limestones includes prominent ledges 3 miles southeast of Kerby, as well as several on Cheney Creek, where they occur under favorable conditions for handling and getting to Grants Pass by a haul of 12 miles.

The second belt is less regular. It extends from the vicinity of Gold Hill southwestward by the Oregon Bonanza mine to the Oregon Caves and beyond into California.

The third belt, with several readily accessible ledges on Kane Creek, appears to the southwest on Applegate River, on Steamboat Creek, and in the vicinity of Whisky Peak, where the belt enters California.

The fourth belt of limestone appears on Little Applegate River, and possibly also on Applegate River near Watkins, where a prominent limestone ledge occurs close to the mica schist, which it appears to overlie.

Age of limestone.—The limestones at a number of points are fossiliferous, but the fossils are too poorly preserved to permit definite determination. In two lots—one from the Happy Camp trail, 10 miles south of Waldo, and the other from sec. 19, T. 37 S., R. 6 W., about 10½ miles southwest of Grants Pass—corals are abundant, and among them E. M. Kindle recognizes with doubt forms that he com-

pares with *Favosites nitella* and *Cladopora robusta*, as well as a gasteropod resembling *Loxonema bella*. Mr. Kindle remarks that if these determinations are correct the beds represented are of Devonian age. It thus appears that the Cheney Creek and Gold Hill belts of limestone (the first and second noted above) are of Devonian age. A striking feature that occurs locally in some of the limestone ledges of the second belt is the inclosure of vesicular volcanic fragments, which indicates that volcanic eruptions occurred in the region at the time the limestones were forming.

In the third belt of limestone, which outcrops along Kane and Steamboat creeks, the only fossils found were fragments of round crinoid stems; the fourth belt, on Little Applegate River, contains both round and pentagonal crinoid stems well preserved. The general absence of other fossils from these two belts suggests a difference in age from the Devonian, and it is probable that they are either Carboniferous or Triassic.

Composition of the limestones.—For the purpose of showing the adaptability of these limestones to the manufacture of cement the following analyses were made by R. C. Wells in the chemical laboratory of the United States Geological Survey at Washington:

Analyses of limestone from Grants Pass quadrangle, Oregon.

	Sec. 19, T. 37 S., R. 6 W.	Carter's quarry, sec. 2, T. 37 S., R. 3 W.	Householders' quarry, sec. 2, T. 37 S., R. 3 W.	Ridge 1 mile southwest of Gold Hill, sec. 20, T. 36 S., R. 3 W.	Marble southwest of Williams, sec. 31, T. 38 S., R. 5 W.	Sec. 7, T. 41 S., R. 4 W., on Applegate River south of Watkins.	Three miles S. 70° E. of Kerby.
Specimen No	7015A.	7017A.	7017B.	7021	7025	7045	7074
Calcium oxide (CaO)	55.28	55.71	55.34	41.83	55.55	55.05	55.38
Carbon dioxide (CO_2)	43.57	43.54	43.23	32.57	43.63	43.25	43.51
Water (H_2O)	.50	.37	.56	.46	.26	.50	.40
Silica (SiO_2)	.23	.37	.31	23.86	.13	.53	.06
Alumina and iron oxide ($[Al, Fe]_2O_3$)	.28	.20	.44	.32	.38	.52	.62
Magnesia (MgO)	.03	.01	.03	Trace.	None.	Trace.	Trace.
	98.89	100.20	99.91	99.04	99.95	99.85	99.97

With the exception of No. 7021, these limestones are nonmagnesian and pure, and are well suited for the manufacture of cement. Shales that appear to be suitable to combine with the limestone to make cement occur convenient to the railroad in the Bear Creek portion of the Rogue River valley.

Relation of Paleozoic to adjacent rocks.—The succession of sediments included in the four belts of limestone and associated rocks, to judge from their attitude and distribution, appears to be conformable throughout, although these strata are apparently unconformable not only with the underlying mica schists but also with the overlying Jurassic rocks.

JURASSIC ROCKS.

The Jurassic rocks of this region consist mainly of shales and thin-bedded sandstones in variable proportion. Small beds of fine siliceous conglomerates are rarely present. The shales are dark, locally black, but weather gray, yellowish, or brown, and here and there are decidedly slaty. The sandstones are gray and hard. Locally in the sandstones quartz veins are abundant, but usually they are scarce or absent. The fine conglomerate of quartzose pebbles contains, on its weathered surface, small cavities from which soluble pebbles have disappeared. Near the contact with granite these rocks are, in places, altered to mica schist. They occupy only a small portion of the region under consideration, in the vicinity of the stage road from Wilderville to Kerby, and their distribution indicates that they unconformably overlap the Paleozoic rocks.

CRETACEOUS ROCKS.

The Cretaceous rocks are comparatively soft conglomerates, sandstones, and shales that once formed a conspicuously unconformable blanket-like covering over a large part of the region, but erosion has removed all of it excepting a few small patches that cling on the older rocks in the neighborhood of Jacksonville and Waldo, where the conglomerate at the base is locally auriferous and mined as a placer.[a]

That these auriferous conglomerates are Cretaceous (Horsetown and Chico) is clearly shown by the fossils contained in the overlying sandstones and shales.

TERTIARY ROCKS.

The Rogue River valley contains a mass of soft sandstone of Tertiary (Eocene) age. It is decidedly arkose near the base and, lying between the Cretaceous strata on the west and the lavas that make up the Cascade Range on the east, it contains the beds of coal best exposed in the vicinity of Ashland and Medford.

IGNEOUS ROCKS.

In the Applegate region igneous rocks are much more abundant than sedimentary rocks and are of comparatively few types, embracing greenstone, serpentine, granodiorite, dacite porphyry, and augite andesite.

The rocks included under the general term greenstone are of several different kinds, but for the most part they agree in being

[a] Lindgren (Am. Jour. Sci., 3d ser., vol. 48, 1894, p. 275) describes an auriferous conglomerate of Jurassic age in the Sierra Nevada of California, and Turner notes one of Chico age in Oregon.

much altered and greenish in color. When fresh and fully crystalline the greenstone is commonly like a gabbro composed essentially of pyroxene and lime-soda feldspar, but it may contain hornblende and resemble diorite, or have ophitic structure and pass into diabase, or be compact like basalt. Much of the greenstone, too, is locally vesicular and this feature, occurring in rock associated with beds of fragmental volcanic material, shows clearly that a large part of the fine-grained greenstone is of volcanic origin, and its relation to the fossiliferous limestones noted above indicates that the volcanoes from which it came were active, some in the Paleozoic era and others in the Mesozoic. These volcanic greenstones of various ages have been cut by numerous dikes and irregular masses of intrusive rocks of the same kind, and the whole has been so crushed and veined by later earth movements in the process of mountain building that it would be very difficult to map these rocks in detail separately.

A few irregular masses of serpentine cut the older greenstones. For the most part they have resulted from the alteration of peridotite or pyroxenite, but some may have come from a basic phase of the greenstone.

Granodiorite similar to that which covers a large area in the vicinity of Grants Pass forms irregular masses and dikes at a number of places. It is composed chiefly of plagioclase feldspar, quartz, and hornblende, generally with more or less mica and orthoclase feldspar, and with the increase of hornblende it varies in color from fine gray to greenish black.

The dacite porphyry is a light-colored rock which in composition and origin is closely related to the granodiorite. It forms dikes, and, though widely distributed, is not abundant. Some of it is decidedly porphyritic, with phenocrysts of feldspar and quartz.

The augite andesite is a dark-colored rock that occurs in a few small dikes cutting all the other igneous rocks as well as all the sedimentary rocks up to the top of the Horsetown.

The relative age of the igneous rocks, aside from the Paleozoic and Mesozoic greenstone lavas, is fairly well established. The greenstones are the oldest, followed in order by the serpentines (peridotites), granodiorite, dacite porphyry, and augite andesite. Although some of the greenstone lavas, and perhaps, also, some of the intrusive greenstones, are Paleozoic, the bulk of the intrusive rocks, including greenstones, granodiorite, peridotite, and dacite porphyry, belong about the close of the Jurassic. The augite andesite is the only igneous rock in the region under consideration that cuts the Cretaceous sediments.

STRUCTURE.

The strike of the strata older than the Cretaceous is generally northeast and southwest, parallel to the rock belts, and their dip for the most part is to the southeast, though in many places they are vertical. To judge from the position of the strata alone it appears that those in the northwest portion of the Grants Pass region should be the oldest, and that they should decrease in age to the southeast. Just the reverse, however, is the case. The youngest rocks (Jurassic) are on the northwest, and the oldest (mica schist) on the southeast, with the Paleozoic between. This apparent reversal of the natural order is due either to folding and overturning of the strata or to faulting, by which the older rocks are made actually or apparently to overlie the younger. It is very probable that both folding and faulting have contributed to the complex structure of the region, but the part played by each is practically unknown and can be determined only by detailed investigation.

The most probable line of faulting noted in the region is one which crosses it from northeast to southwest in the vicinity of Waldo and Kerby, where the Jurassic strata appear to pass beneath the Devonian. A similar line of displacement may occur in the southeastern portion of the Applegate region, between the Paleozoic rocks and the mica schists; but the evidence thus far observed is not conclusive. Both of these supposed lines of faulting have been traced by Hershey southward through the Klamath Mountains, and are shown on the geomorphic map of the California earthquake commission.

METALLIFEROUS MINERAL RESOURCES.

By G. F. Kay.

INTRODUCTION.

The mineral resources of the area under consideration are chiefly gold and copper, the former occurring in gold-quartz veins and in placer deposits. Small amounts of silver are associated with the gold, and from the placers some platinum is obtained. Stibnite, josephinite, and cinnabar have been found, but not in sufficient quantities to be profitably worked. The region in which these minerals occur lies within Jackson and Josephine counties, and covers considerably less than half of their area. The mineral production of these two counties in 1907 had a value of $443,370. Of this amount about 75 per cent came from the mines of the area here described. For that year the value of the production of the copper mines was greater than that of the gold-quartz mines but less than that of the placers.

GOLD-QUARTZ MINES.

GENERAL DESCRIPTION.

The most productive gold-quartz mines which were in operation in this area during the summer of 1908 were the Braden and the Opp.[a] The Granite Hill and Mountain Lion mines, although not now being worked, have also been fairly important producers within the last few years. There are many mines and prospects on which work is not now being done, some of which have never produced, some of which have produced values of a few hundred dollars, and a few of which have produced values of several thousand dollars. At present some development is in progress on new prospects and on mines which were until recently closed. The total gold production of the gold-quartz mines of the area in 1907 was about $70,000.

The gold-bearing quartz is widely distributed and occurs in small veins, veinlets, and brecciated zones, in several kinds of rock. Most of the mines and prospects are in the greenstones, but some are in the granodiorites, some in metamorphosed sediments, and a few prospects in peridotites or their decomposition product, serpentine. The ores are found in several relationships in these rocks. In some places they occur in greenstones at considerable distances from other kinds of rock; in others, they are in the greenstones but at the contact with or near to granodiorites and related rocks. Some veins are parallel to the schistosity in the greenstones. Again, some veinlets are in both greenstones and sediments, and in such occurrences, it is not unusual to find rich ores near the contact of these rocks and closely related to dikes which cut them. This relationship of the rich ore to dikes is also shown where the veinlets are in sediments only. In the peridotites some of the veinlets are at the contact with or near to dikes related to granodiorites.

Many of the veins and veinlets have never produced important bodies of ore but only "pockets," some of which, although filling but small spaces, were remarkably rich, the gold usually having been coarse. In general, the main part of the gold in these pockets has been taken from depths less than 25 feet from the surface.

The veins and veinlets run in all directions. However, a comparison of the more persistent of them showed that more lie in an east-west direction than in a north-south direction. The dips of the veins vary greatly; most of them have fairly high dips, but some are nearly flat and some are vertical. The widths of the veins are usually less than 1 foot; a great many are considerably less, and in some places they form an intricate network of stringers. On the other hand, there are veins with widths of more than 10 feet; in such veins

[a] The Opp mine was not examined.

either " horses " are present, separating the vein into several parts, or there is a decided brecciation of the materials.

The vein filling consists mainly of quartz, which is usually of a milky-white color. In many of the veins the quartz has crystals with perfect outlines, indicating that the deposition took place in open fissures. Calcite is frequently found with the quartz, and subordinate amounts of sulphides, chiefly iron pyrites, but not uncommonly arsenopyrite, chalcopyrite, and galena are also present. A few of the veins contain pyrrhotite. The sulphides rarely exceed 3 per cent of the ores. At the Jewett mine, near Grants Pass, and the Homestake prospect, on Lightning Gulch, a branch of Canyon Creek, gold tellurides occur.

A study of the fillings of the veins in different kinds of rock suggests that the nature of the country rock has not, to any appreciable extent, influenced the contents of the fissures. The gold is present as free gold in the quartz and also associated with the sulphides and tellurides, the concentrates at times being rich.

Few values have been found in the country rocks adjacent to the veins. These rocks are in some places only slightly altered, but in other places they have been chloritized and in still others the products of alteration consist of carbonates, albite, quartz, and pyrite. The presence of albite rather than sericite, a mineral frequently found in the wall rocks of the gold-quartz mines of California,[a] is, no doubt, due to the fact that the Oregon rocks, as indicated from the analyses thus far made, are considerably richer in sodium than in potassium.

The lower limit of the zone of oxidation is in general less than 100 feet below the surface, but in places it exceeds 200 feet.

The evidence suggests that the gold-bearing veins are younger than the early Cretaceous and older than the Eocene, but some of the veins associated with the Paleozoic rocks may be pre-Cretaceous.

DESCRIPTIONS OF THE CHIEF MINES AND PROSPECTS.

BRADEN MINE.

The Braden mine is in the SE. ¼ sec. 27, T. 36 S., R. 3 W., about 3 miles from Gold Hill. It is now owned by C. R. Ray, of Tolo, but during the past year it has been leased to the Opp Mining Company, of Jacksonville. I am indebted to E. W. Liljegran, mines manager for Mr. Ray, for information with regard to this property.

This mine was located about twenty-five years ago by B. A. Knott, of Gold Hill. He began development, the ores being treated in an arrastre. The ownership of the mine passed in succession to several persons, one of them being Dr. James Braden, after whom the mine is named. He sold to Mr. Ray in 1900. The greatest production

[a] Lindgren, Waldemar, Trans. Am. Inst. Min. Eng., vol. 30, 1901, p. 665.

of this mine for any one year was in 1907, when the value of the output was more than $30,000.

The equipment of the mine consists of a 10-stamp mill, one giant crusher, four Johnston concentrating tables, one air compressor, and machine drills. The plant is equipped with an electric power system, the power being brought from Tolo, on Rogue River, a distance of about 5 miles. The property has been developed mainly by drifts along the vein and by winzes and upraises from these drifts. The vein outcrops along the southeastern slope of a hill and dips southeastward. The angle of dip of the vein is greater than the angle of slope of the hill; hence the lower drifts on the vein are at greater depths below the surface than those higher up on the vein. There are four main drifts, one above another. The aggregate length of these drifts is nearly 3,000 feet, and the greatest depth below the surface—less than 250 feet—is in a winze from the lowest of these drifts. The longest drift is the lowest on the vein. It has a length of more than 1,200 feet, and considerable high-grade ore has been taken from the winzes and upraises made from it.

The rocks in which the ores are found are fine grained and of a dark-gray color; in hand specimens small crystals of feldspar may be seen. Under the microscope the rock appears distinctly porphyritic, the groundmass being microcrystalline. The phenocrysts are mainly plagioclase feldspar, but a few crystals of hornblende, probably secondary from augite, are also present. This rock is related to the greenstones, a large area of which lies in a northeast-southwest direction in this part of Jackson County. The area widens rapidly toward the south. The main part of this large area of greenstone is thought to be volcanic rocks interbedded with Paleozoic sediments. The evidence in favor of these rocks being volcanic consists of the presence, in many places, of amygdaloidal and tuff-like characters. Where such characters are absent it is difficult to distinguish those greenstones which are of volcanic origin from those which are fine-grained intrusives.

The vein in which the ores are found strikes about N. 30° E. The average width of the vein is not more than 2 feet; in places it pinches entirely; in other places, instead of one distinct vein with definite walls, there is a brecciated zone, which varies from a few feet to more than 15 feet in width. Within this zone the aggregate width of the quartz veinlets does not exceed 3 feet. In general, the dip of the vein is about 25° SE., but in some places it is nearly flat and in others the angle of dip is high. There are several faults, but they are of small throw—usually from 1 foot to 3 feet, rarely as much as 20 feet. These faults are approximately parallel to one another.

The vein filling consists chiefly of quartz and sulphides; a very subordinate amount of calcite is present. The most abundant sul-

phide is pyrite, but arsenopyrite, chalcopyrite, and galena occur in small quantities. The best values are found in those parts of the vein which are richest in sulphides; where the quartz is comparatively free from sulphides, the gold content is low.

During 1907 the average yield of concentrates was 1 ton from every 12.2 tons of crude ore; these concentrates had an average value of $26 a ton. The average gold and silver content of more than 3,700 tons of ore treated in 1907 was worth about $9 a ton; the silver content was worth only about 22 cents a ton. About 65 per cent of the values of the ores was saved by amalgamation and about 25 per cent by concentration; the remaining values were lost in the tailings. The concentrates were shipped to Selby and to Tacoma.

The main part of the production of the mine has come from two shoots, which are nearly 600 feet apart on the lowest drift of the mine. One of the shoots extended along the vein in this drift for about 55 feet, but in a winze its width increased to about 80 feet, below which it narrowed rapidly. The direction of the shoot was the same as that of the dip of the vein. The other shoot had a length along the strike of the vein of 75 feet; in a winze from it the length increased to 125 feet; at the bottom of the winze, which was run 200 feet below the drift, the values were low. The direction of this shoot was about S. 50° E. Usually the best values were found along the foot wall of this shoot, although in places the values were uniformly distributed across the vein, which here had an average width of about 18 inches.

The zone of oxidation does not extend to a depth greater than about 100 feet below the surface, and in parts of the vein sulphide ores are found at depths considerably less. Along the fault planes the ores show enrichment.

GRANITE HILL MINE.

The Granite Hill mine is in sec. 29, T. 35 S., R. 5 W., near the north boundary of the Grants Pass quadrangle. A good wagon road runs from Grants Pass to the mine, a distance of about 9 miles. At the time of my visit (July, 1908) this mine had been closed for several months and all the workings were filled with water. From Mr. C. M. Morphy, the former superintendent, many of the following facts were obtained. The mine is now owned by the American Goldfields Company, which also owns the property in the vicinity, including the Red Jacket and Ida mines, on which several hundred feet of development work has been done. The present owners obtained the Granite Hill property in 1901, and almost all the development work has been done since that time. During the years 1904 to 1907 the value of the production was more than $65,000. the largest output having been in 1905.

The mine is equipped with a 20-stamp mill, which has a capacity of 100 tons a day; a crusher, concentrating tables, engines, compressors, hoists, machine drills, and a Worthington mine pump. Electric power was used. When the mine was in operation as many as 50 men were employed.

The mine was developed by workings which aggregate nearly 3,000 feet. A vertical shaft of 420 feet intersects the vein at a depth of about 120 feet. From depths of 200, 300, and 400 feet on the shaft crosscuts were run to the vein and drifts made along the vein. The profitable ore between the levels was stoped out and raised through the shaft to the surface.

The country rocks are related to the granodiorites, a narrow tongue of which extends southward into the Grants Pass quadrangle from a larger area of these rocks in the Riddles quadrangle. To the east of the granodiorites is greenstone; to the west, serpentine. At the Granite Hill mine the values have been found only in the granodiorite, but at the Red Jacket and Ida mines they occur in the greenstone.

The vein runs in an east-west direction and has an average width of about 5 feet. In places the vein is brecciated, the fractured zone having a maximum width of about 20 feet. The dip of the vein is about 70° S. The vein filling consists of quartz, pyrite, chalcopyrite, and galena, carrying gold. The sulphides comprise about one-half of 1 per cent of the ores, and as concentrates they yield about $75 to the ton. The average gold value of all the ores treated in 1907 was about $5 a ton.

Mr. Morphy stated that the richest ores were found in shoots, of which there were three, each having a length along the vein of about 150 feet and a direction of dip to the west of south.

The zone of oxidation extends to a depth of more than 200 feet from the surface, and from the oxidized ores the best values were obtained.

MOUNTAIN LION MINE.

The Mountain Lion mine is in the western part of sec. 1, T. 38 S., R. 5 W. It was discovered in 1889 by the Messrs. Bailey, who, with Messrs. Davidson, Jewell, and Harmon, are the present owners. No work has been done on the property for several months. The equipment consists of a 5-stamp mill, with concentrating tables, compressor, and engines. When the mine was in operation, as many as 25 men were employed.

The property has been extensively developed, there being about 8,000 feet of crosscuts, drifts, and other workings. Work has been done on two veins, which are in greenstone and slates and which are close to the contact of these rocks, with an area of granodiorite. The

slates occur as narrow lenses in the greenstones, and the best values of the veins have been obtained near the contacts of the greenstones and the slates. The better-defined vein of the two has a direction of N. 80° W. and dips 65° S. It averages about 1 foot in width and is faulted at many places. The vein filling consists chiefly of quartz, calcite, and sulphides, the sulphides constituting about 1 per cent of the whole. Owing to the prevalence of faults the vein has been difficult to follow.

TIN PAN MINE.

The Tin Pan mine is in the SE. ¼ sec. 31, T. 36 S., R. 3 W., on the divide between Galls Creek and Foots Creek. The property was located many years ago. It is now owned by the Pacific American Gold-Mining Company. T. T. Barnard was superintendent during the summer of 1908.

The mine is equipped with a 10-stamp mill, a Blake crusher, and two concentrating tables. No large body of profitable ore has been found, although more than 1,200 feet of drifts, shafts, and other workings have been made on the vein.

The country rocks in which the ores occur are slates, limestones, and greenstones, the greenstones apparently being intrusive in the sedimentary rocks, although some of them may be volcanic. The direction of strike of the sediments is about N. 13° E. The strike of the vein is between northeast and east, and the dip is nearly vertical. The width of the vein varies from less than 18 inches to more than 6 feet of solid quartz between definite walls, which are usually but slightly altered. In places there is a gouge from 1 to 3 inches in width. This material is clay like, but it contains carbonates and sulphides. The chief values of the vein are in the sulphides, which run about $60 to the ton. The sulphides are pyrite and galena, which together constitute less than 2 per cent of the ores. Some faulting has occurred.

The zone of oxidation reaches a depth of more than 100 feet.

STAR MINE.

The Star mine is in sec. 6, T. 39 S., R. 4 W., west of Thompson Creek and about 4 miles from Applegate post-office. This property was located in 1896 by J. J. Kunutzen. Very little development work was done until 1904, when E. B. Hawkins and Harry N. Morse became the owners. They spent about $20,000 in development. Thus far only about 800 tons of ore has been milled. The gold content was low, running only from $2 to $4 a ton.

The ore was quarried from an area of fine-grained greenstone in which there were numerous small stringers of gold quartz running in various directions. No distinct vein was found.

MAID OF THE MIST MINE.

The Maid of the Mist mine is in sec. 4, T. 39 S., R. 4 W. It is owned by William Wright, who did considerable work on the property during 1906, but suspended operations in May, 1907. During the summer of 1908 it was bonded by the South Oregon Mines Company, and preparations were being made to conduct extensive developments. More than 500 feet of work, mainly in shafts and drifts, had already been done, and compressors and hoists were being installed.

The country rock is greenstone. The gold-bearing quartz occurs in veinlets, which run in various directions. One of the most persistent of these runs N. 85° W. and dips 55° S. The values are irregularly distributed through the quartz, which is fairly free from sulphides. Of the sulphides, arsenopyrite appears to be more prevalent than pyrite. Calcite is subordinate.

JEWETT MINE.

The Jewett mine is close to the boundary between secs. 27 and 34, T. 36 S., R. 5 W., about 4 miles from Grants Pass. It was discovered about 1880 by Thomas Jewett. It now belongs to the estate of Benjamin Healy, of San Francisco. During the summer of 1908 no work was being done, but J. T. Hoare, the superintendent, stated that development was soon to be resumed. A short distance from the mine is a 5-stamp mill. There are seven claims, on which more than 1,500 feet of work has been done.

The country rocks are intrusive greenstones closely related to gabbro. Near the workings a dike of granodiorite cutting the gabbro was observed. The ores do not occur in a vein with definite walls, but in small stringers in a brecciated zone, which is irregular both in direction and in width. The most pronounced direction is about N. 20° W. In places the width of the zone of brecciation is more than 20 feet. The filling between the fragments of the breccia consists chiefly of quartz and calcite, the latter being subordinate. Irregularly distributed through the quartz is a small amount of pyrite, pyrrhotite, and a glistening steel-gray mineral, which when boiled with concentrated sulphuric acid gives the purplish-colored reaction characteristic of a telluride. The properties of the mineral correspond to those of sylvanite. It was found without difficulty in several tons of ore on the dump.

HOMESTAKE PROSPECT.

The Homestake prospect is on the main branch of Lightning Gulch, a tributary of Canyon Creek, which flows into Josephine Creek about 4 miles above its junction with Illinois River. It was formerly owned

by the Lewis and Clark Gold Mining Company, but is now owned by the Homestake Mining Company, of which E. A. McPherson, of Kerby, is manager.

The chief development on this property is a tunnel about 180 feet long. The country rock is a somewhat siliceous greenstone, which is in places decidedly schistose. Veinlets parallel to the schistosity contain quartz and calcite, with which are associated native gold, gold telluride, and iron pyrites. The values are irregularly distributed, some of the ores being rich. The strike of the schistosity is north and south; the dip is 65° E.

OTHER MINES AND PROSPECTS.

Not far from the Homestake are other prospects from which gold tellurides are reported. Of these the Booth prospect, on the west fork of Lightning Gulch, and the Challin & Finch prospect about 1½ miles from the head of Canyon Creek, are the most important.

There are several other mines and prospects which might be described, but they would present no new features. Among such may be mentioned the Michigan mine, Bill Nye mine, Lawrence mine, McMurtry mine, Alice group, Gold Pick mine, Gardner prospect, Pratt prospect, Millionaire mine, Oregon Bonanza mine, Oregon Belle mine, Gray Eagle prospect, and Owl Hollow prospect. On the first seven of these no work has been done for some time; on each of the others a small amount of development is being done. Chief among the "pockets" of ore that have been found within the area are the Gold Hill, the Roaring Gimlet, the Revenue, the Steamboat, and the Harrison. The locations of these are shown on the map.

CONCLUSIONS.

The gold-quartz veins and veinlets of this area are in all important features similar to those of the Riddles quadrangle, which were described in Bulletin 340 of the Survey. Of the many veins and veinlets on which work has been done few have developed into profitable mines, and the outlook for profitable gold-quartz mining in the region is not encouraging. This unpromising condition is due to the structural features of the rocks of the area. These rocks, previous to the mineralization, had been so fractured and fissured by earth movements that later, when precipitation took place from the gold-bearing solutions passing through the rocks, the gold was widely disseminated and not concentrated into definite lodes such as are favorable to gold-quartz mining. Moreover, the difficulties of mining have been increased by faulting subsequent to the formation of the veins. To the widespread distribution of the values, however, is due the fact that placer gold is found in so many of the streams of this part

of the country. The veins and veinlets carrying the gold have been undergoing erosion for many thousands of years, and during this time the gold has been carried by water and by gravity into the stream beds, from which it has been and is being mined.

PLACER MINES.

GENERAL OUTLINE.

The placer mines of Jackson and Josephine counties produced in 1907 gold to the value of $229,575, of which $107,722 came from Jackson County and $121,853 from Josephine County. More than 75 per cent of the production of Jackson County and more than 30 per cent of that of Josephine County came from the area described in this report. The chief districts contributing to this production are the Gold Hill, the Foots Creek, the Applegate, and the Jacksonville districts, in Jackson County; and the Althouse and Sucker Creek, the Williams Creek, the Waldo, and the Kerby districts, in Josephine County.

The gravel deposits that are being mined in these districts vary in thickness from a few feet to more than 50 feet. The average thickness of the gravels of all the important mines is more than 20 feet. The material of the deposits ranges from fine clay with but few bowlders to gravels that contain bowlders weighing several tons. The bowlders are, as a rule, fairly well rounded where the gradients of the streams are steep, but where the gradients are flatter, they are subangular and even angular. The predominating bowlders in the gravels are greenstone, but the kinds of bowlders vary in the different stream beds in accordance with the various kinds of rock in which the valleys have been cut. In many of the deposits the coarsest material is at or near the bed rock, but in some the bowlders are somewhat uniformly distributed throughout the section of the gravels.

With but one exception the placers are in gravels closely associated with the present streams, the deposits being either in the present stream beds or on terraces not many feet above them. The exception is at the High Gravel or Allen Gulch mine, near Waldo. Here the gravels are of Cretaceous age and lie on the divide between the east and west forks of Illinois River.

The gold content of the gravels varies greatly. In some of the best mines the average value is from 20 to 40 cents a cubic yard. The best values have usually been found at or near the base of the deposit. Much of the gold is fine, but nuggets are frequently found.

Many of the placer deposits have a bed rock of greenstone, which is in places considerably decomposed, fractured, and fissured, many of the fissures being filled with veinlets of quartz. But the gravels containing the gold are by no means confined to areas of greenstone.

Some of the placers have a bed rock of granodiorite, some of serpentine, and some of slate. In the Waldo district gravels are being mined which lie on Cretaceous conglomerates and sandstones. Much of the material of the deposits has been transported for considerable distances, and hence its origin bears no immediate relation to the rock on which it now lies. As the greenstones are the most widespread rocks of the region and as from them much of the gold of the quartz mines has come, it is reasonable to conclude that much of the placer gold has come from the veins and veinlets of the greenstone areas. But inasmuch as gold-bearing quartz is found also in other kinds of rock in this region, these have, no doubt, contributed gold to the placers. The usual slope of the bed rock is about 150 feet to the mile.

Placer mining is carried on chiefly during the first half of the year, when the supply of water is most abundant. A few mines are so equipped that there is sufficient water to operate them for a greater part of the year. Only one mine, the Champlin, on Foots Creek, is equipped for dredging; the other important mines are equipped for hydraulicking. The ground-sluicing method is used only in the small mines.

In many of the mines from three to five men are employed, but as many as fifteen are employed in some of the larger mines during the mining season.

GOLD HILL DISTRICT.

In the Gold Hill district there are no large placer mines. The most important is the Blockert mine, on Galls Creek. On the same stream work is being done on a few other properties. The gravels worked are in the present stream bed. The hydraulic method is used. On Sardine Creek also some mining is being done.

It is of interest to note that during the summer of 1908 preparations were being made to mine, by electric dredge, deposits to the south of Kane Creek, in the SW. $\frac{1}{4}$ sec. 36, T. 36 S., R. 3 W. The Electric Gold Dredging Company, of which H. A. Mansfield, of Indianapolis, is manager, had already begun work. The electric power shovel to be used is equipped with three motors, one for hoisting the dipper, one for swinging the crane or boom, and one on the crane or boom for crowding the dipper into the bank. The capacity of the shovel is about 500 cubic yards in ten hours. The electric power is brought from the Ray dam on Rogue River, 2 miles away. The water to be used in washing the gravels is obtained from reservoirs on the small stream which flows through the property. The material of the deposit is fine-grained clay and gravel having an average thickness of about 18 feet; very few bowlders are present. The bed rock is slate with a strike of N. 55° E. and a dip of about 70° SE. The slates have been considerably altered.

FOOTS CREEK DISTRICT.

There are several placer mines on Foots Creek. Of these, the chief producer is the Champlin mine, located on the creek just below the forks. The other mines are the Black Gold Channel and Cook, on the Left Fork, and the Lance and Glen Ditch on the Right Fork. For the notes on the mines on the forks I am indebted to Mr. Diller.

CHAMPLIN MINE.

The Champlin mine is on Foots Creek, about 2 miles from its junction with Rogue River. It is owned by the Champlin Dredging Company, of Chicago, which bought the property in 1903 from Mr. Lance, of Gold Hill. In the same year the company constructed a bucket dredge equipped with steam power. In November, 1905, electric power was installed, the cost of mining being thereby reduced about one-half. Thirty-six buckets are used, each of which holds 8 cubic feet of material.

The average depth of the pay gravel is about 35 feet, but deposits to depths of 46 feet have been mined without reaching bed rock. Much of the material is less than 5 inches in diameter, but bowlders of large size are numerous. The best values are found in a bluish gravel, which is generally reached at a depth of about 12 feet. This gravel is from 8 to 18 feet in thickness. Below it is a fine plastic clay, which is difficult to handle, and which carries practically no gold. In the present workings this clay is not being mined. The property contains more than 1,200 acres of placer ground, much of which has been thoroughly prospected and found to carry gold.

BLACK GOLD CHANNEL MINE.

The Black Gold Channel mine is on the Left Fork of Foots Creek, in sec. 12, T. 37 S., R. 4 W. It is leased at the present time. In the bank is exposed about 15 feet of unstratified gravels, coarsest below, and containing bowlders up to 18 inches in diameter. There is very little fine material; the bowlders, which are almost all of greenstone, are subangular to fairly well rounded. The large bowlders are handled by a derrick. Two giants are used under a head of several hundred feet. The gravels are forced upward for 15 feet over an elevator, but the sluice takes the material 2½ feet above bed rock. The mine pit of the present workings has an area of 1½ acres. A large area down the stream has already been worked over. The bed rock is slate cut by dikes of greenstone. The strike of the slates is N. 10° E.; distinct joints run about N. 70° W. Numerous small veins are present, and have a general northeast-southwest direction.

COOK MINE.

The Cook mine is in the S. ½ sec. 13, T. 37 S., R. 4 W. The pay gravel is, in places, plainly stratified, and consists mainly of fine gravel and clay. The stream bed has been mined for one-fourth of a mile. The bed rock is made up of greenstone and slates cut by numerous greenstone dikes. It has been greatly sheared and faulted. One fault runs N. 75° W. and dips 31° N.; another runs N. 53° E. and has been traced for nearly one-fourth of a mile.

LANCE MINE.

The Lance mine is on the Right Fork of Foots Creek, in the SE. ¼ sec. 22, T. 37 S., R. 4 W. It is owned by the Lance Brothers, but is leased at present. The bank has in places a thickness of 20 feet; much of the material is fine. The bed rock consists of lenses of limestone in slates, which are cut by dikes of greenstone. The bed of the stream has been mined for about one-third of a mile, and there is still considerable good ground to be mined.

GLEN DITCH AND OTHER MINES.

The Glen Ditch mine is near the head of the Right Fork of Foots Creek. It is owned by Boling Brothers. The stream bed has been followed for some distance, but much good ground remains to be worked. The gravels are about 15 feet thick.

Other small producers on the Right Fork are the Mattis and Hausman mines.

APPLEGATE DISTRICT.

The chief mines of the Applegate district are located on small streams flowing into Applegate River. The most important are the Layton mine, on Ferris Gulch; the Johnston and the Benson mines, on Humbug Creek; and the Brantner mine, near the mouth of Keeler Creek.

LAYTON MINE.

The Layton mine is part of the estate of J. F. Layton. The average thickness of the gravels is about 25 feet and the width, from rim to rim of the pay channel, is more than 200 feet. In much of the material the pebbles are less than 6 inches in diameter and are usually subangular. The largest bowlders are in the bottom of the deposit and in places they are considerably decomposed. The best values are found in an old channel about 15 feet below the level of the present stream bed. In this channel the fall is about 4 feet in 100 feet. The gold is usually in small flakes, but nuggets are also found. The bed rock is greenstone, which in places is distinctly vesicular

and greatly fractured and veined. Some of the veinlets are as much as 4 inches in width. Narrow bands of slaty rock are interbedded with the volcanic rocks, which have a strike of about N. 40° E. and dip to the southeast.

Mining is carried on each year from February until September. The early miners had a small ditch with a head of 100 feet, but Mr. Layton put in two ditches, the upper of which is 21 miles long and the lower 18 miles. The water of both ditches comes from Williams Creek. Two giants are used under a head of about 300 feet. Five men are generally employed, and the amount mined off each year is somewhat more than 1 acre. The property was secured by the present owners in 1877 and since that date mining has been carried on each year. A considerable area of good ground remains to be washed.

JOHNSTON MINE.

The Johnston mine is in sec. 11, T. 38 S., R. 4 W., at the junction of the west branch with the main Humbug Creek. The present owner is W. H. Johnston. The bank averages about 8 feet in thickness and contains considerable clay, in which the main values are found. Bowlders of greenstone and granodiorite, from 6 inches to more than 8 feet in diameter, are present. Much of the mining has been confined to the bed of the stream. The bed rock consists of fine-grained greenstone, much fractured and veined. The mine is equipped for hydraulicking, the waters being brought from Humbug Creek. The supply of water is so scanty that, in general, the mine can not be operated for more than three months each year. Mining has been done on this stream for more than thirty years, during which time more than 30 acres has been mined.

BENSON MINE.

The Benson mine is on Humbug Creek in sec. 14, T. 38 S., R. 4 W. It is owned by S. L. Benson. The property consists of about 1 mile of the stream bed. The gravels are about 20 feet in thickness and contain many large angular and subangular bowlders, which are rather uniformly distributed throughout the section of the deposit. The gold is found mainly in the bottom. The bed rock is greenstone. This mine has been in operation for many years, but was not equipped for hydraulicking until the spring of 1908.

BRANTNER MINE.

The Brantner mine is on Applegate River, near the mouth of Keeler Creek. It is owned by D. H. Mansfield. In the present workings the sands and gravels have a thickness of 30 to 35 feet and show

distinct stratification. Many large angular and subangular bowlders are found at and near the base of the deposit. All the material above this is fairly well rounded and contains few bowlders. The bowlders are chiefly of greenstone and are comparatively unaltered. The surface of the terrace now being worked is about 40 feet above Applegate River. The bed rock is decomposed greenstone. The mine is equipped for hydraulicking, the water used having a pressure of about 100 feet. The large bowlders are handled by derrick. There is sufficient water to operate the mine for about three months of each year. Altogether, more than 20 acres have been mined, and considerable good ground remains to be washed.

JACKSONVILLE DISTRICT.

In the Jacksonville district is the Sterling mine, the most productive placer mine of southwestern Oregon; also the Old Sturgis, the Spaulding, and the Pearce.

STERLING MINE.

The Sterling mine is on Sterling Creek, a branch of Little Applegate River, and is about 8 miles from Jacksonville. It is owned by the Sterling Mining Company, of which J. D. Heard is manager. The property includes about 2,000 acres, extending from a point below the mouth of Sterling Creek to the head of Sterling Creek and over the divide to Griffin Creek. The gravel bank on the west side of the present workings is more than 40 feet in thickness, but on the east side it is only about 20 feet thick. The section consists of gravel and bowlders, the latter being rather uniformly distributed throughout the section. Many of the bowlders are small, but some are more than 2 feet in diameter and a few exceed 8 feet. They are mainly of greenstone.

Much mining has been done on Sterling Creek by the present company. The main stream was mined up from its mouth for more than 3 miles, then a channel to the east of this stream was followed for about half a mile. Here a channel, which is named Bowlder Channel, was struck, and this has been followed for about a quarter of a mile to the present workings. The bed rock of these workings is a little higher than the present stream bed and is about 100 yards east of it. The values are found across a width of nearly 200 feet. The gold is of medium coarseness and is usually well rounded, although angular nuggets are also present. The average thickness of the gravels in the Bowlder Channel is about 40 feet. It is of interest to note that in these gravels the tusks and jaws of a mammoth, as well as other mammalian bones, have been found. The bed rock at the mine is greenstone, in which are patches of slaty tuffs. These rocks have been con-

siderably sheared and veinlets of quartz are present. The strike of the slaty rocks is N. 8° E., the dip about 60° W. In the present workings is a dike running N. 20° E., containing cross veins which do not extend beyond the dike. The slope of the bed rock is about 2 feet in 100 feet. In 1908 mining was in progress from March until August, during which time about 1 acre was mined. The value of the gravels was about 40 cents to the cubic yard.

The mine is well equipped with ditches, giants, and flumes. The longest ditch is about 27 miles in length. The water enters the ditch from Little Applegate River about 12 miles above the mouth of Sterling Creek. At the mine the head of the water is now only about 80 feet. A pipe line is being planned to carry water from Squaw Lake to the mine, a distance of 17 miles. The mine has been equipped for hydraulicking for about thirty years. The Sterling Mining Company was incorporated in 1872. There were issued only 40 shares of stock, which have been held by a very few shareholders. The total production of the mine is said to exceed $3,000,000.

SPAULDING MINE.

The Spaulding mine is on Forest Creek in sec. 4, T. 38 S., R. 3 W. The maximum thickness of the deposit in the present workings is more than 40 feet, but the average thickness does not exceed 25 feet. The lowest 10 feet consists of gravels containing bowlders; the upper part of the deposit is hardpan. Even in the lower part there are but few bowlders, and these are usually less than 1 foot in diameter. They are rounded or subangular and are usually of greenstone, although some are of granodiorite. The mine is equipped for hydraulicking.

OLD STURGIS MINE.

The Old Sturgis mine is on Forest Creek in sec. 10, T. 38 S., R. 3 W. It is now owned by the Sterling Mining Company. G. L. Jones is the foreman. The deposit has an average thickness of about 30 feet; the maximum thickness is about 60 feet. In the lowest 10 feet are gravels and sand containing rounded and subangular bowlders, which are chiefly of greenstone, although some are of granodiorite. The upper part of the deposit is hardpan, which has a reddish to buff color. The gold is fine, and the best values are near the bottom. The richest ground is said to run as high as $12,000 to the acre. The bed rock is greenstone much fractured and veined; in places it is very slaty, the strike being N. 30° E. and the dip 48° SE. In the mine pit the bed rock is about 8 feet above the stream bed and the slope is very gentle. The water supply is such that the mine may be operated from one to four months each year. The

main ditch is about 1½ miles in length. The mine is equipped with giants, and a derrick is used for handling the bowlders. About 1 acre a year is mined. From 8 to 12 men are employed. The property contains about 900 acres, a large part of which is placer ground. For many years the mine was owned by the Vance Mining Company.

PEARCE MINE.

The Pearce mine is on the east fork of Forest Creek in sec. 11, T. 38 S., R. 3 W. The gravels have an average thickness of about 12 feet, but in places they have been 45 feet thick. Where recent work has been done the bank is about 25 feet thick. In the lowest 6 feet of the deposit there are many large undecomposed bowlders, but above this zone the material is gravel and sand not very strongly cemented. The best values are at and near the bottom. In general the gold is rather fine. Some of the ground has run as high as $7,000 to the acre. The bed rock is greenstone, the slope of which is not more than 2 feet in 100 feet. The mine is equipped for hydraulicking, three giants being used. The pressure of the water is only about 85 feet. The water is brought 1½ miles from the upper part of the stream on which the mine is located. A derrick is used for handling the bowlders. The property consists of 240 acres, a large part of which remains to be worked.

In addition to the mines on Forest Creek already described, there are some other small producers. In the early days of placer mining in Oregon, Forest Creek was among the most productive streams.

ALTHOUSE AND SUCKER CREEKS DISTRICT.

From the gravels of Althouse and Sucker creeks a large amount of gold was washed in the early days of placer mining in Oregon, but for several years the production has not been great, as the best ground was worked many years ago. During 1907 the production of the streams of this district probably did not exceed $6,000. There are no large mines, but numerous small ones. Among these are the Jumbo, the Mountain Slide, the Slide, and the Yeager, on Sucker Creek and its branches. On Althouse Creek some work is being done on the Layman property, and recently the Klamath Development Company acquired eight claims near Grass Flat, on which considerable work is to be done. Some new ground was also being opened at the mouth of Portuguese Gulch, a small branch of Althouse Creek near its head.

WILLIAMS CREEK DISTRICT.

The chief placer mines in the Williams Creek district are the Horsehead mine, on a branch of Williams Creek, the Miller & Savage mine, on Miller Creek, and the Oscar placer, on Oscar Creek.

HORSEHEAD MINE.

The Horsehead mine is in the SE. ¼ sec. 21, T. 38 S., R. 5 W., and is owned by Alexander Watt. The gravels vary in thickness from a few feet to 30 feet, with an average of about 18 feet. The deposit contains many angular and subangular bowlders considerably more than 1 foot in diameter. These are somewhat uniformly distributed throughout the section. Many of the bowlders are greenstone, but some are granodiorite. The finer materials are of a grayish to reddish color. The values are distributed through the gravels and as a rule the gold is fine. The bed rock is granodiorite, which has been fractured and crushed and in places has been disintegrated and decomposed to a depth of more than 10 feet. An area of more than 10 acres has been mined. The property is equipped for hydraulicking. The water is brought from Munger Creek, the ditch being 8 miles long.

MILLER & SAVAGE MINE.

Miller & Savage's mine is on Miller Creek in sec. 25, T. 37 S., R. 5 W. The gravels vary in thickness from 6 to 30 feet, with an average of about 18 feet. Many bowlders exceeding 1 foot in diameter are present, the largest of these being at the bottom of the deposit. The gold is mostly fine, but nuggets of large size have been found. The largest of these was found several years ago and is said to have weighed more than 13 ounces. The mine is equipped for hydraulicking. The present owners have mined each year since 1904, and considerable good ground remains to be washed.

OSCAR CREEK MINE.

The Oscar Creek mine is on Oscar Creek, a small stream which flows into Applegate River. The property comprises more than 300 acres. The gravels have an average thickness of about 12 feet and contain many rounded bowlders of medium size. The materials are not strongly cemented. The gold is found in flakes and in nuggets. The equipment consists of two giants, 1,100 feet of pipe, 300 feet of flume, and 3 miles of ditches. The supply of water is sufficient to carry on operations for about four months of the year. It is said that the property has produced more than $35,000.

WALDO DISTRICT.

In the Waldo district there are three important placer mines, the High Gravel or Allen Gulch mine, the Deep Gravel mine, and the Logan, Simmons & Cameron mine.

HIGH GRAVEL MINE.

The High Gravel mine is about 1 mile south of Waldo on a ridge which forms the divide between the east and west forks of Illinois River. The summit of the ridge is about 1 mile from the east fork and is more than 300 feet above it. The chief workings are at the head of Allen Gulch, on the east slope of the ridge. The most recent workings, however, are on the west slope of the ridge. Of the summit of the ridge a width of only about 100 feet remains to be mined.

This mine is of unusual interest in that the deposits do not belong to the present stream bed or adjacent benches but are conglomerates which are, according to Mr. Diller, who has made a study of the geology of the region, of Cretaceous age.

The deposits mined on the west slope run parallel to the ridge. They are more than one-eighth of a mile in length and have an average width of about 100 feet. The conglomerates do not extend down the slope but constitute only a remnant which here has escaped erosion, as is true of other areas of conglomerate in the region. No conglomerate remains on the summit of the ridge a short distance to the north of the present mine pit. The surfaces on which the conglomerates were laid down were uneven, and hence the thicknesses of the conglomerates vary. The maximum thickness exposed is more than 60 feet. The conglomerates have a purplish tint. They are not strongly cemented and the bowlders are rather uniformly distributed throughout the section. Much of the material is less than 1 foot in diameter; a few bowlders are more than 3 feet. Distinct joints are present in the conglomerates, and a few small veinlets occur. The bed rock is a fractured, fissured, decomposed, and veined greenstone, which, owing to the presence of iron oxides, has a decidedly purplish tint.

The workings on the east side of the ridge extend down Allen Gulch to the east fork of Illinois River, but only those gravels which are near the summit of the ridge are of Cretaceous age. These conglomerates extend along the ridge in a north-south direction. At the south end of the workings they are more than 50 feet in thickness; at the north end and close to the summit of the ridge they are only a few feet thick, and a little farther on they have been completely eroded. The best values are said to be near the bed rock, but some gold is found higher up in the deposit.

These Cretaceous conglomerates are shore deposits, derived from older rocks, similar to those on which they now lie. As stringers carrying values are fairly widespread in these old rocks, some gold is probably present in much of the conglomerate which has been derived from them. But whether or not these values are sufficiently concen-

trated, as at the High Gravel mine, to be profitably mined can be determined only by prospecting.

It is of interest to note that some placer mines in northern California are in conglomerates of Cretaceous age.[a]

DEEP GRAVEL MINE.

The Deep Gravel mine is about 1 mile northwest of Waldo. The property comprises about 560 acres in secs. 20, 21, and 28, T. 40 S., R. 8 W. It is owned by the Deep Gravel Mining Company. The main workings are in Butcher Gulch and its tributary gulches. The gravels of these gulches are included in a bench which extends from the head of Butcher Gulch to the west fork of Illinois River. The upper limit of the bench is about 1½ miles from the west fork and about 125 feet higher than the bed of this stream. The most recent workings are in Joe Smith Gulch, an eastern tributary of Butcher Gulch, where an area of more than 10 acres has been mined. At the upper end of these workings the gravels are about 12 feet in thickness; at the lower end they are more than 60 feet and the bank consists of gravel and sand containing practically no bowlders except in the lowest 10 feet, and even there few of them exceed 1 foot in diameter. Stratification is well shown. The bed rocks in Joe Smith Gulch consist of purplish conglomerates of Cretaceous age, similar to the conglomerates that are being mined at the High Gravel mine. As these conglomerates of the Deep Gravel mine have not yet been well prospected, their gold content is not known.

The mine pit of Joe Smith Gulch is 1,500 feet from the west fork of Illinois River. The elevation of the bed rock in the mine pit is more than 30 feet below the stream bed of the west fork, a fact that has greatly increased the difficulties of mining, necessitating the use of a hydraulic elevator. The elevator is situated at the lower end of a sluice with riffles. The pay gravel from the bank is first washed through the sluice, the coarse gold being caught on the riffles. Then the material including the fine gold is carried up 46 feet by the elevator, the water pressure used being about 200 feet. At the head of the elevator is a 4-foot flume, 400 feet in length, in which are wooden riffles placed about 1¼ inches apart and parallel to the length of the flume. A beveled steel strip is attached to the upper surface of each riffle. These steel strips are slightly wider than the riffles and, when they are set in place, are about three-fourths of an inch apart.

A clean-up is made about once a month. The gold is saved by amalgamation and is very fine. The concentrates are sold for their values in platinum, osmium, and iridium. Mr. Wimer, the presi-

[a] Eng. and Min. Jour., vol. 76, pp. 653–654.

dent of the company, stated that the average value of the pay gravels during the last five years had been about 25 cents to the cubic yard.

The water used in the pit and in the elevator is brought by two ditches from the east fork of Illinois River. The longer of the two ditches is about 4 miles in length. There is on the property a race about 7,000 feet long that was used for many years when the gravels being mined were at an elevation greater than that of the outlet of the race. At present only the lower end is used.

The history of the Deep Gravel mine dates back for more than thirty years. The first owners were George and Walter Simmons. In 1878 Wimer & Sons bought a half interest and in 1888 they secured all rights to the property. In 1900 the Deep Gravel Mining Company became the owner. Mr. Wimer stated that about $130,000 has been expended on the property and that the output of the mine has been about $250,000.

LOGAN, SIMMONS & CAMERON MINE.

The Logan, Simmons & Cameron mine is northeast of Waldo, the present workings being in sec. 22, T. 40 S., R. 8 W. J. M. Logan is manager. The recent workings are on French Flat, where about 3 acres has been mined. Here the bank consists of gravel, sand, and clay, with a thickness varying from a few feet to 15 feet. Much of the material is fine; only a few bowlders are present, nearly all of which are less than 6 inches in diameter. The bed rock is purplish Cretaceous conglomerate, which has been fractured, fissured, and to some extent veined. The slope of the bed rock is very gentle.

An elevator which raises the material 38 feet is used. There are three ditches. The water from one of these has a pressure of 325 feet and is used in the elevator; that from another is used in two giants in the pit; and that from the third ditch is used in forcing the tailings from the end of the sluice at the head of the elevator. Mining is carried on for about eight months of the year.

The old workings on this property are in Carroll Slough, more than a mile north of the present pit on French Flat. The gravels have been mined in a north-south direction for more than a mile; the average width is about one-eighth mile, the average depth about 18 feet. The gold content was about 12½ cents to the cubic yard. The bed rock is made up in some places of serpentine and in others of Cretaceous conglomerates and sandstones.

This mine has been operated for about twenty-five years, but not until the last season was work begun on French Flat, where there is a considerable area of auriferous gravels. The present owners have operated the mine for the last eight years. Mr. Logan stated that during that time the value of the output has been about $50,000.

KERBY DISTRICT.

The chief placer mine of the Kerby district is the Anderson & Wilson property on Illinois River about 6 miles from Kerby. Other producers are the Ray mine, which adjoins the Anderson & Wilson mine on the south, and, on Josephine Creek, the Flintlock mine, Morrison Brothers' mine, and the Josephine and Illinois Gold Mining Company's mine.

ANDERSON & WILSON MINE.

Anderson & Wilson's mine is on the east bank of Illinois River above the mouth of Deer Creek. The gravels are in benches adjacent to the river. The bed rock of the workings farthest down the stream is but little higher than the bed of the river. The gravels are about 20 feet thick and in places have been mined for a distance of about one-eighth mile back from the stream, where the slope rises steeply and the limit of the bench is reached. The sand and gravels are of a buff color and are well stratified. The largest bowlders are in the lowest 6 feet of the deposit.

The most recent work has been done on gravels lying south of those just described, about 50 feet above the level of Illinois River. The workings run parallel to the river for about 200 yards and extend back from it for about 150 yards. The gravels vary in thickness from a few feet to 25 feet. The upper part of the deposit is rather fine sand and gravel; below this there are many bowlders. Stratification is well shown.

The bed rock is serpentine. The water is brought from Fidler Gulch, a branch of Josephine Creek. It is conveyed across the Illinois at the mine in a large pipe.

OTHER MINES.

The Flintlock mine, Morrison Brothers' mine, and the Josephine and Illinois Gold Mining Company's mine are all equipped for hydraulicking. Their combined output in 1907 had a value of a few thousand dollars.

COPPER MINES.

According to returns from the smelters, Oregon produced 545,859 pounds of copper in 1907. Of this amount, by far the larger part was derived from the ores of Josephine County and the remainder from the ores of Grant County. The entire output of Josephine County came from one mine, the Queen of Bronze, in the Waldo district. Some good ore had been taken from several small mines adjacent to this one, but operations on these mines have been suspended for some time. During the summer of 1908 very little work was being done at the Queen of Bronze mine, but preparations were being made for more extensive developments.

QUEEN OF BRONZE MINE.

The Queen of Bronze mine is located in sec. 36, T. 40 S., R. 8 W., about 6 miles from Waldo and 2 miles from Takilma. It is owned by the Takilma Smelting Company, of Colorado Springs, Colo., and was superintended by C. E. Tucker.

The rocks with which the ores are associated are gabbros, peridotites, and serpentine. These rocks are widespread in southwestern Oregon. The peridotite, which consists chiefly of enstatite and olivine, is in many places intruded in the gabbro; in other places the peridotite and gabbro appear to be products of differentiation of the same magma, there being no sharp line between those rocks which are rich in olivine and pyroxene but have no feldspar and those which are olivine gabbros and gabbros, the last named containing chiefly plagioclase feldspar and pyroxene but no olivine. Locally the peridotite grades into pyroxenite. The compositions and field relationships of these rocks clearly indicate that they are closely related genetically. In some places the peridotites and related rocks are fairly free from decomposition, but over large areas they have been altered to serpentine, which usually has a greenish-yellow color and shows slickensided surfaces. At a few places the serpentine is itself undergoing decomposition, one of the products of alteration being magnesite. The peridotites, gabbros, and serpentine almost everywhere shows the effects of earth movements. They are fractured, fissured, and jointed, and in many localities are decidedly brecciated. The soil formed from these rocks is in general of a reddish color and supports a scant vegetation.

The outcrops of the ore deposits consist of gossan, the oxidized materials varying in depth from a few feet to more than 100 feet. The ore bodies have no definite form but occur as irregular masses in the gabbro, the peridotite, and the serpentine. These masses or pockets of ore appear to have no definite relationships to one another but occur irregularly in the fractured and fissured rocks. Most of the ore bodies, however, that have been found on the Queen of Bronze and adjacent claims lie in a zone that extends for several miles in a north-south direction and has a width of less than 1 mile. The largest single body of unoxidized ore mined at the Queen of Bronze mine contained about 10,000 tons. Practically all of it came from a depth of less than 30 feet. Other masses of unoxidized ores have been taken from depths of about 100 feet. Although depths of about 300 feet have been reached in the workings, no important body of ore has been found below 125 feet. Several occurrences of slickensided ores were observed, and in some places the ore contains small veinlets of calcite.

The unoxidized ore is chalcopyrite, with which are associated pyrite, pyrrhotite, and subordinate amounts of quartz and calcite. In the low-grade ores pyrite and pyrrhotite are the most abundant minerals. In addition to the copper content, the ores carry some gold and silver.

The oxidized ores are malachite, azurite, cuprite, tenorite (?), and chrysocolla. Of these the black ores, containing tenorite or chalcocite, are most abundant. Several thousand tons of oxidized ore has been mined. The average content in copper was more than 10 per cent. The lower limit of the oxidized ores is usually less than 90 feet from the surface, but some have been found at greater depths. In a small opening about 105 feet below the surface black oxide and small amounts of native copper were observed. The zone of oxidation is invariably deeper where the rocks have been serpentinized than where the country rocks are fairly fresh.

These ore bodies are apparently the result of precipitation from mineral-bearing solutions which entered the rocks after they had been fractured and fissured by earth movements. Whether these solutions were set free from cooling magmas as they solidified to form igneous rocks or whether they were of meteoric origin it is impossible to determine. Although dikes cutting the peridotite and gabbro were not observed in the vicinity of the mine, their presence in other areas of these rocks would suggest that the solutions may have been associated with the magmas from which the dikes were formed. In places in the serpentine below the zone of oxidation chalcopyrite with slickensided surfaces has frequently been found. The chalcopyrite appears to have been subjected to all the movements which accompanied the process of serpentinization. This indicates that the ores are older than the serpentine.

The mine is more than 20 miles from Grants Pass, which is the most accessible point on the railway. The only means of transportation between Grants Pass and the mine is by wagon; consequently the rates for hauling machinery, provisions, and other materials for the mine and coke for the smelter have been high. This fact has been unfavorable to the development of the property. The mine is situated on the slope of a ridge. The smelter is at the base of the slope 500 feet below the mine and 1½ miles from it. The ores, when taken from the workings, are trammed to bins, from which they are transferred to wagons and hauled to the smelter.

The equipment at the mine consists of three boilers, an air compressor, a hoist, and two machine drills. The mine has been developed by tunnels, drifts, and open cuts. The chief workings are related to two gossan-covered areas on the claim. The northern and more extensive workings are near the north boundary of the claim; the other workings are about 1,200 feet farther south.

The northern workings consist of two tunnels, from which considerable drifting has been done, and a large open pit. The upper tunnel, which is about 400 feet long, enters the west slope of the ridge and runs eastward beneath an area of decomposed and brecciated gabbro, in which are oxidized ores. At no place does this tunnel have a vertical depth of more than 90 feet from the surface. In this tunnel and in drifts and winzes from it some large irregular-shaped masses of chalcopyrite, but practically no oxides, were obtained. From the tunnel an upraise was made to the oxidized ores. This upraise was then used as a chute. The oxidized ores were mined to the surface by overhand stoping, passed through the chute, and carried out by tram through the tunnel. Several thousand tons of oxidized ores were mined in this way, the large open pit thus formed having an area of about 120 by 120 by 80 feet. Where the tunnels and other workings were in the serpentine, great care had to be taken in timbering. The lower tunnel also enters the west slope and is about 190 feet below the upper tunnel. In it and in drifts from it more than 1,100 feet of work has been done. Only a small amount of ore was found in these workings.

The southern workings consist of a large open cut, a tunnel, which runs underneath this cut, and a 106-foot shaft. From the open cut about 10,000 tons of unoxidized ore, carrying about 7 per cent of copper, was taken. The zone of oxidation was only a few feet in depth. The ores mined were passed through a chute from the bottom of the pit to the tunnel and then trammed to the bins. From the tunnel and the shaft only a small amount of profitable ore was mined.

All the ores that have been mined have been smelted at the Takilma smelter, which is under the same ownership as the mine. The smelter is of the pyritic matte type and has a capacity of 100 tons a day. The charge used was about 1,500 pounds of ore, 350 pounds of limestone, and 200 pounds of coke. The limestone used had to be hauled about 2 miles. The matte from the ores smelted in 1907 contained about 40 per cent of copper.

The Queen of Bronze property was acquired in 1903 by the present owner. Only a small amount of development had been done on the property previous to its acquisition. In all about 30 claims are owned by the company. Including the cost of the smelter, more than $150,000 has been spent on the properties. Mr. Tutt, the president of the company, stated that more than 20,000 tons of ore had been smelted and that the average copper content had been about 8½ per cent. The gold content of the ores has been worth more than $3 a ton, the silver content about 17 cents a ton. Ore was first smelted from this property in 1904. The greatest production was in 1907.

OTHER COPPER MINES.

As already stated, there are several small mines adjacent to the Queen of Bronze mine, and owned by Mr. Tutt and his associates. Considerable development has been done on these properties, and from three of them—the Cow Boy, the Lyttle, and the Mabel—about 4,000 tons of ore has been smelted. The characters of the ores, their modes of occurrence, and their associations are similar to those of the Queen of Bronze mine.

Some distance to the northeast of the Queen of Bronze mine is a prospect owned by Doctor Spence. On this property considerable work has been done and some good ore has been found.

PROSPECTS OF STIBNITE, JOSEPHINITE, AND CINNABAR.

Within the area here described stibnite, josephinite, and cinnabar have been found in small quantities.

A stibnite prospect is located in the SE. ¼ sec. 24, T. 40 S., R. 4 W., about 3 miles north of Watkins, on Applegate River. It is owned by C. M. Buck, of Watkins. The ore occurs in the fractures of a fine-grained brecciated greenstone. From a trench about 50 feet long and a tunnel about 25 feet long several tons of good ore has been mined. Where the ore is exposed the antimony sulphide is being changed to antimony oxide.

The mineral josephinite has been found only in the placers of Josephine Creek, in Josephine County. It is an alloy of iron and nickel, containing 60.47 per cent of the latter.[a] When the mineral is polished it has the appearance of metallic iron or nickel. Although it has not been found in the rocks, the mineral in the placers has probably come from the serpentine through which the stream has cut its channel.

A small prospect of cinnabar, the sulphide of mercury, is located on Palmer Creek, a western branch of Applegate River. Although a considerable amount of the mineral is reported to have been found with the gravels of the stream, very little has yet been found in the surrounding rocks.

[a] Am. Jour. Sci., 3d ser., vol. 43, p. 509.

NOTES ON THE BOHEMIA MINING DISTRICT, OREGON.

By Donald Francis MacDonald.

INTRODUCTION.

The Bohemia mining district is in Lane and Douglas counties, west-central Oregon. It lies on Calapooya Mountain, in the western foothills of the Cascade Range. The district is about 30 miles southeast of Cottage Grove, a small town on the Southern Pacific Railroad. The Oregon and Southeastern Railroad runs from Cottage Grove to Disston, within 12 miles of the mines, which are reached by stage.

In August, 1908, the writer made a short stay in this district and incidentally to other work visited some of the larger mineral properties. For some of the data presented herein he is indebted to Mr. J. S. Diller, of the United States Geological Survey, who made a reconnaissance of the region in 1898,[a] and for many courtesies to Messrs. L. D. Ryan, F. J. Hard, W. W. Warner, and other mining men of the district.

PHYSIOGRAPHY AND GENERAL GEOLOGY.

The relief of the district is pronounced. Several peaks are more than 6,000 feet high, and the elevation of the lowest valleys is less than 2,000 feet. This bold relief is the result of mountain glaciation and stream erosion. The luxuriant vegetation due to the humid climate has somewhat masked the geologic features of the region. Great forests clothe the mountain slopes and the region is notable for its timber value.

The rocks of the district are andesitic lavas and tuffs of Tertiary age, which are cut by dacite porphyry and probably by basalt. The andesites are the most abundant rocks. Seven consecutive flows, aggregating 500 feet in thickness, appear on the south face of Bohemia Mountain. They vary from light to dark gray in color and in hand specimens show small elongated phenocrysts of feldspar and very small greenish crystals of pyroxene or chlorite. In weathering the rock assumes a light-gray to buff color, the feldspars becoming white and powdery. Good exposures of andesite are shown on Bohemia, Elephant, Fairview, and Grizzly mountains.

[a] The Bohemia mining region of western Oregon: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, pp. 7–64.

The tuffs, in the main, are of andesitic composition and at many places are interbedded with andesite flows. A tuff composed of coarse fragments occurs near the White Ghost claim on City Creek. Fine tuff interbedded with lava is shown in the crosscut to No. 2 level in the Noonday mine. The slope east of Horseheaven Creek shows a considerable area of light-gray stratified tuffs. Fine gray banded tuffs were seen on the slopes below Judson Rock. These tuffs are contemporaneous with the andesites, particularly with the later flows.

A light-gray rock, probably dacite porphyry, cuts the darker andesites and tuffs in many places. This rock on fresh fracture shows minute aggregations of quartz, larger crystals of feldspar, and small dark crystals of pyroxene and hornblende. The fine groundmass between the large crystals is gray to slightly greenish, the green tinge being due to the presence of chlorite. This dacite porphyry cuts andesites and interbedded tuffs at several places along the road about halfway between Disston and Orseco. It also occurs within half a mile of the Musick mine, both to the northeast and to the southeast.

Basalt occurs in one or two small outcrops. It is a fine-grained, dark lava, best shown on the south edge of Bohemia Mountain. Its small outcrop suggests that it is intrusive in the andesite.

ORE DEPOSITS.

The ore deposits of this district are fissure veins, which cut the andesites and tuffs. Small sulphide impregnations also occur in the vicinity of altered diabasic dikes, but they have no economic value. The general strike of the veins is north to northwest, with a dip of 60° to 85°. They vary from 1 foot to 12 or 15 feet in width. Some are single veins; others consist of two or more parallel veins, separated by a few inches to a few feet of highly altered country rock. At the Musick mine there are three parallel veins, 1 to 4 feet in width, separated by thin walls of altered country rock. Only the fissure veins which have suffered postmineral fracturing have produced profitable ore. These veins, because of their oxidized and easily workable condition, gave good returns in free gold in their upper workings. Veins which have not been fractured since they were mineralized, or which are situated in regions of maximum erosion, such as old glacial cirques, show sulphide ores at the surface. They are tightly cemented and relatively impermeable and represent the conditions of mineralization that prevail in all the veins below the oxidized zone. The minerals which they contain are sphalerite, pyrite, a little galena, and very little chalcopyrite, with a gangue of quartz, altered country rock, and some calcite. So far these veins have not been found profitable, because their sulphide ore can not be cheaply treated, the tightness with which the ore is cemented makes mining more expensive, and the gold tenor is less than that of the oxidized material.

HYDROTHERMAL METAMORPHISM.

In the vicinity of the veins the mineralizing solutions have greatly altered the country rock. Several hundred feet distant from a vein the dark color of the rock is in many places changed to a greenish tinge, while close to the deposit it is gray to buff in color, has a clayey appearance, and crumbles easily. The pattern of the rock is fairly well preserved, however, the outlines of the feldspar phenocrysts being clearly visible, though the feldspar material has been changed to a white or yellowish powder.

Under the microscope it is seen that the basic feldspars have altered into sericite, calcite, and quartz, the quartz, however, being in relatively small quantity. The ferromagnesian minerals have been changed to calcite and the iron in them appears now as limonite or hematite. Farther away from the vein, where metamorphism was less intense, these minerals have reached only the chloritic stage of alteration. In many veins soft disintegrated country rock forms a considerable part of the vein matter. An examination of this material showed that near the surface it is composed essentially of very fine granules of quartz with considerable iron-stained kaolin. At greater depth the same rock contains an abundance of sericite and calcite with very little kaolin.

SECONDARY ALTERATION AND ENRICHMENT.

Some of the veins were brecciated after they were filled, and as a result oxygenated surface waters were able to percolate downward along the fractured zone. The ores were thus oxidized and sulphides leached out to depths of 100 to 300 feet, depending on the degree of brecciation and the rate of erosion. The gold occurred as threads and filaments included in the pyrite. The pyrite was leached away, leaving the relatively insoluble gold and some iron oxide occupying a part of the small cavity left in the vein material. This process brought about an association of free gold with iron-stained, spongy quartz and enriched the ore by leaching out the valueless sulphides. It also rendered the ore soft and porous, so that it is much more cheaply mined and milled than the unaltered ore.

Small local enrichments of free gold occur at the junctions of fissures, pyrite being abundant at these junctions, as shown by the mass of iron oxide left. It is probable that the smaller particles of gold were dissolved from the upper parts of the vein by the ferric sulphate solutions of oxidized pyrite and were precipitated by the local masses of pyrite below.

Some secondary sulphides were observed, but these are of no commercial value. They consist of pyrite crystals deposited in cracks in primary pyrite and of very small masses of sphalerite and galena. Other secondary minerals noted were calcite and, rarely, cerusite.

MINING DEVELOPMENT.

Gold was first discovered in Bohemia in 1858. In 1875 the first mill, a five-stamp battery, was built on the Knott claim. From 1877 to 1891 little was done in the district. In the nineties the Musick, Champion, Noonday, Vesuvius, and several other mines became active, and mills aggregating 35 or more stamps were built. At the time of visit, in August, 1908, no ore was being milled in the district, nor had any milling been done since the previous summer. Several companies, however, had men employed in prospecting and development.

Figures for the total output of the camp are not available. As nearly as can be judged from the statistics published in "Mineral Resources of the United States," and from verbal reports, the total product is probably between $300,000 and $400,000, mainly in free gold. Although some rich shoots occur locally, the average tenor of the ore is low, generally running $3 to $5 a ton. The soft, spongy, iron-stained vein material is cheaply mined and milled. The cost of mining is from $1.50 to $2 a ton, and of milling little over 50 cents a ton. The concentrates range in value from $20 to $70 a ton and consist in the main of auriferous pyrite, with silver and a little lead and copper. Values less than $25 a ton can not be profitably shipped because of present high freight rates.

The principal mines of the region which have produced values are the Musick, Champion, Vesuvius, Noonday, Helena, and California, and there are others of lesser note. The Musick leads in development, with about a mile of drifts along six 50-foot levels. Of these, levels 4 and 6 are reached by short crosscuts which tap the vein from the basin at the head of City Creek. About 2,000 feet to the west, on the other slope of the divide, a portal from one of the lower drifts opens out close to a good stand of mining timber. A shaft 80 feet deep connects directly with the two upper levels and through various stopes with most of the lower workings, thus giving good ventilation to the mine. Most of the ore was hauled out at the lower level, which attains a maximum depth of about 300 feet.

The Champion, Vesuvius, and Noonday have each about half a mile of workings. In the Champion most of the development work has been done on two levels, the lower of which attains a maximum depth of about 200 feet and is reached by a crosscut a few hundred feet in length through which all the ore is brought out. A considerable amount of stoping has been done, particularly where the greatest oxidation occurred. The lower workings here show considerable amounts of primary sulphides. The Vesuvius has been worked from several levels to a depth of about 300 feet and has many stopes. The steep slope on which it is situated has facilitated

its development by tunnels and has afforded a gravity transfer for the ore from stope to mill, as well as good ventilation and drainage for all the workings. The Noonday has three principal levels, all tapped by crosscuts from the steep slope of the Horseheaven basin; the lowest level attains a maximum depth of about 300 feet. Considerable stoping was done and the ore from the stopes was sent down to the mill on an aerial tramway about one-third of a mile in length. The Helena has more and the California somewhat less than 1,000 feet of workings. Both are developed by tunnels which will attain 100 to 300 feet of depth. The Helena has two levels and has produced some very rich specimen ore.

The ore from the Musick mine was hauled over a practically level electric tramway about a mile in length and dumped into the ore bins of the Champion mine. Thence the ore of both mines was sent down to the mill on a steep incline, 3,400 feet long. Haulage was effected by an endless cable to which the mine cars were attached by means of an automatic grab, the loaded cars going down pulling the empties up. The Musick-Champion mill, the largest in the district, has 30 stamps and is run by a water-driven electric generating plant located on Frank Bryce Creek, 7 miles below the mine. It handled the ore from both the Musick and Champion mines. The electric plant was designed to develop 300 horsepower and to operate the stamp mill, a small sawmill, and a local electric-light plant and to furnish mine power. A small auxiliary steam plant is provided for use in case of need. Other milling plants in the district are a 10-stamp mill at the Vesuvius mine, a 5-stamp mill at the El Calado property, and a 20-stamp mill on the Noonday group.

SILVER AND COPPER PROSPECTS.

The Riverside and Oregon-Colorado claims are promising copper prospects which show some good chalcopyrite ore and are located on strong veins. The Combination property covers a somewhat extensive lode, consisting of one large vein and some smaller veins, and is said to have produced ore which assayed more than 25 ounces of silver to the ton.

FUTURE OF THE DISTRICT.

The Bohemia district contains many well-defined veins and lodes. Many of those which show on the surface have not yet been explored, and no doubt many more are obscured by the dense vegetation which covers a large part of the district. It seems reasonable to suppose that other mines will yet be opened, and will find workable gold ore at least in the upper and oxidized portion of the veins. Workable bodies of copper and silver may possibly be discovered in the district.

FAULTING AND VEIN STRUCTURE IN THE CRACKER CREEK GOLD DISTRICT, BAKER COUNTY, OREGON.

By J. T. Pardee.

INTRODUCTION.

The Cracker Creek mining district is situated in the northwestern portion of Baker County, Oreg. It is a small integral part of the Blue Mountain gold belt, which has been described by Lindgren,[a] and as generally understood comprises the drainage basins of Cracker and Fruit creeks. The town of Bourne, 6 miles north of Sumpter, is the principal settlement within the district. The principal mines are the North Pole, Eureka and Excelsior, Columbia, and Golconda, all located, from northeast to southwest in the order named, on one persistent fissure, the North Pole-Columbia vein, or "mother lode," as it is locally designated. At present the Columbia is the only producing mine in the district, but the suspension of operations in most of the others is believed to be temporary and not caused by exhaustion of the ore bodies. In addition to those above mentioned, there are a number of smaller mines and prospects on which annual assessment and considerable development work is being done. Time in which to visit all the mines was not available, but in November, 1908, during the progress of field work in the Sumpter quadrangle, in the northern part of which this district lies, advantage was briefly taken of opportunity to visit the underground workings of the Columbia and North Pole mines, to the managers of which, Mr. Frank S. Baillie and Mr. Emil Melzer, respectively, acknowledgment is gratefully made for courtesies extended.

The aggregate production of the mines on the "mother lode" is estimated to be at least $7,000,000.

TOPOGRAPHY.

All of the district is mountainous. The streams have rather steep gradients and flow through valleys which are for the most part V-shaped, but some of which are U-shaped in their upper courses.

[a] Lindgren, Waldemar, The gold belt of the Blue Mountains of Oregon: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 2, 1901, pp. 551–776.

The dividing ridges are steep and rugged, with narrow, somewhat serrate summits. The minor details of the sculpture express the variations in the hardness of the underlying rocks. Down cutting of the stream beds appears to be generally still in progress. The average depth of the valleys is from 1,000 to 2,000 feet. The altitude of Bourne is 5,400 feet; that of the junction of Cracker and Silver creeks, the lowest point in the district, 5,000 feet; that of the peak at the head of Rock and Sardine creeks, the highest point in the district, 8,400 feet.

The principal topographic features of the area dealt with in this paper are shown in somewhat generalized fashion in figure 3. The spur trending south-southwestward from Elkhorn Ridge and terminating at Bourne has the local name of North Pole Hill. The ridge dividing Cracker and Fruit creeks is locally named at its southern extension Columbia Hill, and this name may be conveniently extended to the whole ridge.

GEOLOGY.

STRATIGRAPHY.

The rocks most extensively developed about the Cracker Creek mines are argillaceous and siliceous sediments, nonfossiliferous so far as known, and very fine grained throughout. The composition of the beds varies from that of chert consisting almost wholly of silica to that of highly aluminous blue-black slate. These types, however, are rarely found in complete purity; they grade one into the other, and are at many places interlaminated, the cherts in particular being divided into thin sheets and lenses by argillaceous partings. Seen in distant views, the weathered outcrops of the sediments everywhere appear rather dark in hue and more or less rusty with oxide of iron. The impression conveyed by a cursory examination is one of monotony and of a lack of sharp lithologic distinctions. Only long-continued and careful observation made it possible to recognize lithologic subdivisions of the stratigraphic column, a task which it was necessary to accomplish before the structure could be deciphered. The series appears to be conformable. It is exposed over the greater portion of the district in the form of a salient surrounded by intrusives. (See fig. 3.)

The rocks of igneous origin are intrusive granodiorite, surrounding the sedimentary area on the north and northwest; some dikes, observed to cut both the argillite and the granodiorite, varying in thickness from a few inches to 20 feet or more, that appear to be mainly altered feldspar porphyries; a few aplitic dikes; some small masses of serpentine; and a greenstone, probably an interbedded lava or intrusive sill. This last-named rock is most conveniently con-

sidered in connection with the sedimentary rocks, which are probably of Paleozoic age.[a]

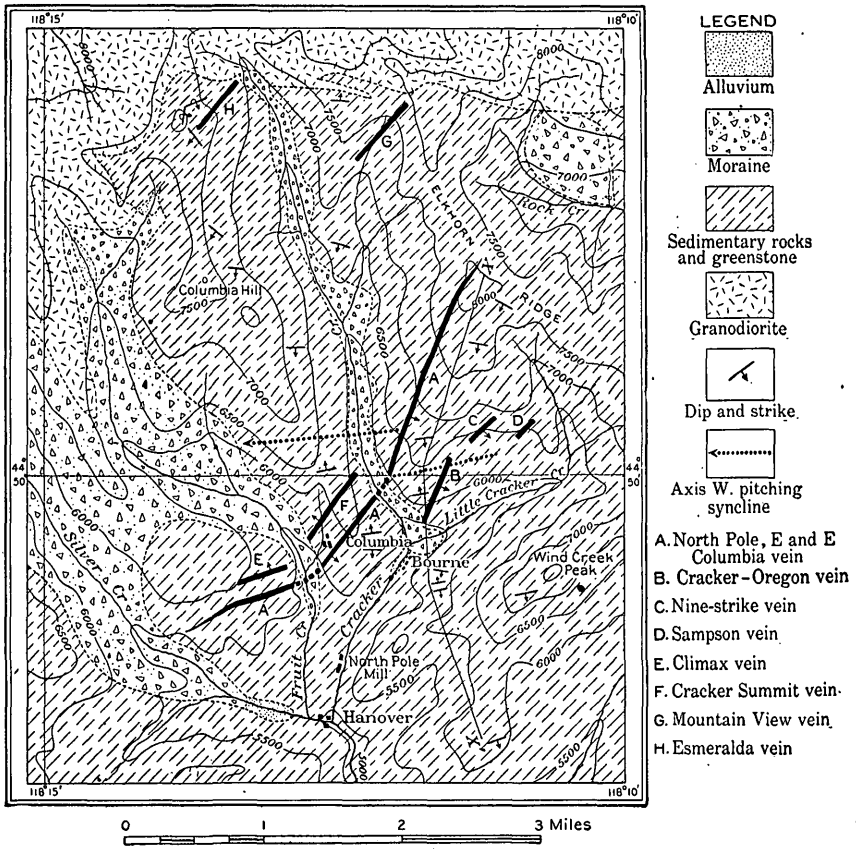


FIGURE 3.—Geologic sketch map of part of Cracker Creek mining district, Baker County, Oreg. Topography from Sumpter atlas sheet.

The following measurements are provisional and subject to correction:

Section of sedimentary rocks and greenstone in Cracker Creek mining district.

[Beds numbered in order of age.]

	Feet.
8. Light to blue-gray siliceous shale. Laminæ 1 to 5 inches thick, irregularly swelling and pinching, separated by very thin dark partings. On weathered surface numerous lighter-colored spots are etched, forming slight depressions and giving outcrops a mottled appearance. Prominent outcrops	100
7. Dark-gray, thinly laminated, rather siliceous argillite, locally mottled as in No. 8 above. Middle portions black with slaty cleavage. Inconspicuous outcrops	600

[a] Lindgren, Waldemar, op. cit.

	Feet.
6. Blue-gray, indistinctly bedded siliceous shale, locally mottled on weathered surface. Moderately conspicuous outcrops	150
5. Dark-gray to black argillite, thinly laminated, conspicuously mottled. Very subordinate outcrops	700
4. Greenstone, a hard, tough, heavy, greenish, massive crystalline rock, of varying texture. Exposed surfaces usually etched, showing irregular rough "warty" prominences of dark-green hornblende, between which are light-gray depressions, these features here and there so arranged as to faintly suggest bedding. Prominent cliffy outcrops	600
3. Black, slaty, thinly laminated argillite with some indistinctly bedded, rather siliceous layers, having mottled weathered surfaces. Inconspicuous outcrops	350
2. Light to warm gray, almost purely siliceous sediments. Laminæ 1 to 3 inches thick; otherwise as in No. 8; prevailingly mottled at top. Forms prominent outcrops	100
1. Prevailingly siliceous, gray to dark-gray sediments, rather indistinctly bedded as a rule, but containing a few beds 4 to 10 feet thick and one 80 feet thick, closely resembling No. 2 above, except that mottling is less conspicuous or absent. Contains also a few thin argillaceous beds. Weathered surfaces gray brown in upper portion to red brown in lower. Prominent outcrops	400+
	3,000

STRUCTURE.

FOLDING.

The most readily noticeable structural feature of the more siliceous of these beds consists of the contortions and small close folds they everywhere exhibit. The black argillites have a slaty cleavage that as a rule coincides with the bedding. Some of them are closely folded also, but as their bedding is less distinct than that of the siliceous rocks their structure is more obscure. The thickening due to small folds has not been estimated, and is therefore not eliminated in the tabular section. As a rule the strike of the beds is N. 80° E. in the southern portion of the district, gradually changing to northwest in the northern portion. The dips are prevailingly south, with local exceptions caused by a westward-pitching syncline exposed in the southern portions of North Pole and Columbia hills. (See figs. 3 and 4.)

FAULTING.

The most noteworthy structural feature is faulting of an extreme distributive type, which is developed throughout the district. This faulting is so common that portions of the district, as for instance the

northern half of Columbia Hill and Elkhorn Ridge, from the summit of North Pole Hill northward to the intrusive contact, may be said to resemble huge fault breccias. The dimensions of the faults descend to the microscopic, and nearly every joint and cleavage plane shows polishing or striæ as evidence of movement.

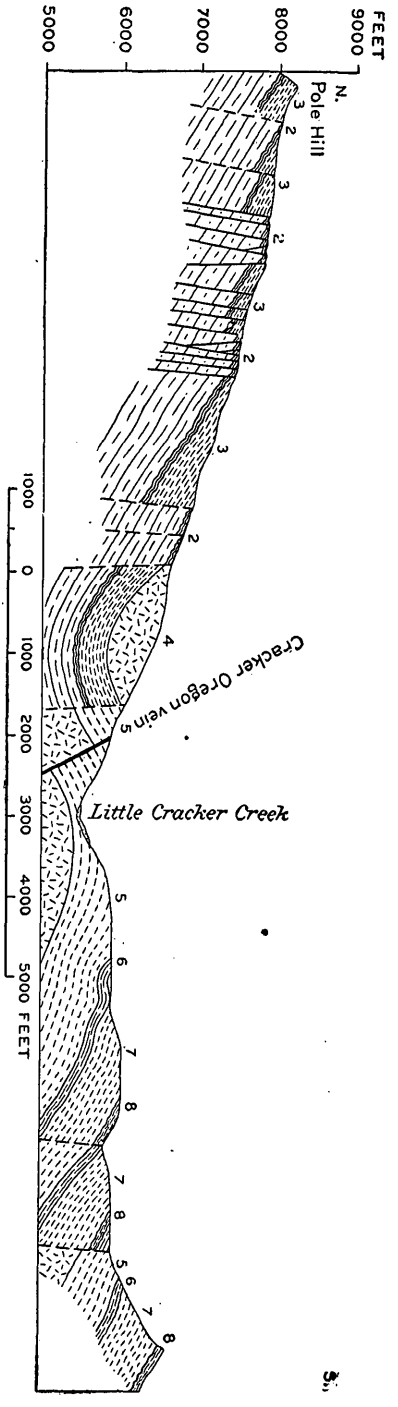


FIGURE 4.—Section along line *A-B*, figure 3. Numbers refer to section on pages 87 and 88.

The observed indications of faulting are the following: (1) Beds are in contact out of their normal sequence. The satisfactory identification of the different beds in this district, where sharp lithologic distinctions are lacking and discontinuous exposures the rule, requires careful scrutiny, and the definite location of fault contacts is best effected by carefully following the more prominently cropping siliceous beds. (2) There are numerous fault breccias, the fragments of which, usually distinguishable from other products of disruption by their polished or striated surfaces, are generally distributed in the surface mantle and, where found in place or nearly so, as on some ridge summits, indicate the positions of faults. (3) Notches, trenches, ravines, and offsets in ridges commonly indicate the positions of faults in this district. (4) Many fault planes may be directly observed on cliff faces and in drifts, pits, etc.

All faults in the district whose attitude has been determined are normal, and steep dips are the rule. Most of them may

be grouped, as regards strike only, in an approximately north-south system; an east-west system, observed in some instances to displace the former; and a northeast-southwest system that includes the quartz veins. In the first two of these groups the movement on any one fault plane may commonly be measured in inches, and the maximum observed does not exceed 100 feet. The sum of these small movements is, however, considerable. For instance, the faults of the east-west system on North Pole Hill within a horizontal distance of 1 mile effect an aggregate downthrow to the north of approximately 2,000 feet. (See fig. 4.) But this summation, it should be noted, takes no account of the horizontal component, which, as shown by the pitch of striæ, enters into the movement in nearly every fault plane.

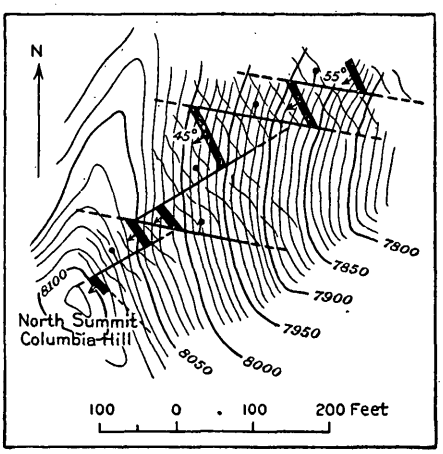


FIGURE 5.—Detail of faulting northeast of Columbia Hill, Baker County, Oreg.

The detail of some of the less complex fault zones may, in favorable places, be mapped, and one near the north summit of Columbia Hill is shown in figure 5. Many of the fault zones are composed of smaller units than this one. An example is one of the east-west faults just south of the lower summit of Columbia Hill. Its aggregate vertical displacement (the horizontal movement not having been estimated) is 400 feet, distributed along a large number of parallel planes, lying 1 inch to a few feet apart, through a horizontal distance of 600 feet.

VEIN SYSTEM.

Only the most superficial observations were made on the smaller veins, the locations of some of which are indicated in figure 3. The Cracker Oregon vein is 4 to 8 feet wide and dips steeply to the southeast. The Cracker Summit vein is 4 to perhaps 12 feet wide and dips 50° to 70° NW. Both are said to have produced pay ore; their vein filling resembles that of the "mother lode" and their walls bear evidence of movement. The Cracker Summit vein has at several points been displaced by faults of the other groups, but the exact details of the faulting have not yet been worked out.

The "mother lode" stands out as a most prominent economic and structural feature. It is a normal fault extending beyond the limits of the district. The portion of it here particularly referred to is that extending from the Columbia shaft to the limit of the North Pole stopes; a distance of 7,500 feet. On this portion of the vein are

located the Columbia, Eureka and Excelsior, and North Pole mines, from southwest to northeast in the order named.

The displacement along this fracture, which in the North Pole dips 70° SE. and strikes N. 34° E., was approximately determined where it crosses Columbia Hill. Here bed No. 4 of the section on pages 69–70 forms the hanging wall and is in contact with bed No. 2 on the foot wall, indicating a vertical displacement of at least 400 feet. But in addition to the vertical throw the fault causes a horizontal displacement of approximately 1,800 feet. This estimate is obtained from the present relative positions of the detached portions of the syncline briefly referred to above and indicated in figures 3 and 4, which the fault cuts nearly at right angles to its axis. The axis of this trough trends approximately east and west and was originally continuous. At present the intersection of the axial plane of the North Pole Hill half of the trough with that of the vein lies about 1,800 feet south-southwest of the intersection of the corresponding plane in the Columbia Hill portion of the trough with that of the vein. This estimate is subject to modification by more careful measurements, but not sufficiently so to disprove the statement that there has been a horizontal displacement of considerable magnitude. The horizontal movement is further indicated by striæ within the vein, as described below. The vein may be said to divide the district into two fault blocks. With respect to the northwestern or Columbia Hill block, the southeastern or Bourne block has settled and moved southwest by south, or along a line lying in the plane of the vein and pitching gently to the southwest.

The large amount of development work that has been done on the "mother lode" offers excellent opportunity for investigation of the structure due to complex movements within the vein.

The Columbia mine is opened by three adit levels and a 900-foot vertical shaft with which crosscuts and drifts connect at each 100 feet. The aggregate of development is stated by Mr. Baillie to be, in drifts and crosscuts, 19,470 feet; in shaft, raises, and stopes, 29,274 feet; total, 48,744 feet.

The shaft is sunk in the hanging wall 45 feet from the vein, which it penetrates at a depth of 800 feet, thus showing the dip of the vein here to be about 86½° SE. Its strike is N. 34° E. Northeast of the shaft the vein is well defined and 20 to 100 feet wide. The ore shoots, 3 to 8 feet in width, are found on the foot wall in all but the upper (adit) levels, where they have crossed to the hanging wall. The pay ore is usually separated from more barren quartz by walls lined with thinly-laminated black gouge. The laminæ are mostly striated. In many places the striæ on one side of the lamina pitch at variance with those on the other side. The directions of movement thus indi-

cated vary from vertical to horizontal, the horizontal component usually predominating. The ore body itself is separated into overlapping wedges or thick lenslike masses by seams of black, laminated, striated gouge. About 200 feet south of the shaft the vein loses its identity in a zone characterized by a great number of faults, most of which strike southwest to west and dip 45° N. or S. The gouge linings of these faults nowhere fail to exhibit evidences of movement as above described. Within this zone isolated masses of ore are found.

The North Pole mine is not at present in operation, having closed down last August. It is developed by five adit levels and one intermediate level, aggregating 12,500 feet, and a large extent of crosscuts and stopes. At 1,800 feet from the mouth of tunnel No. 1 a fault, whose course is N. 18° W. and dip 60° W., displaces the ore shoot 45 feet to the southeast. On following this fault for about 500 feet to the intermediate level, the displacement is noted to be small, and the slip appears to coincide with a flat wall forming the lower boundary of the ore shoot for a distance of about 1,200 feet farther on. This ore body widens above, attaining a maximum of 25 feet just under tunnel No. 3, where a cross section of the vein is as follows:

Section of vein of North Pole mine.

	Feet.
Foot wall; dark-gray siliceous shale.	
Brecciated quartz in black gouge	3
White quartz	40
Finely brecciated unconsolidated ("sugar") quartz	15
Low-grade vein quartz	15
Ore	25
	98

These divisions are separated by polished or striated walls approximately parallel to those of the main vein and bearing abundant, black, laminated, obliquely striated gouge. This ore body abruptly ends to the northeast against a fault plane, striking N. 80° W. and dipping 45° S., which does not penetrate the main hanging wall. Neither does the foot wall appear to have been displaced where the drift turns to it about 120 feet farther on. From this point northeastward for about 400 feet to the face of the drift the foot wall carries small masses of ore that usually exhibit a tendency to branch and disappear in seams leading obliquely upward toward the opposite wall. In the main stope just referred to the ore lies on either wall or occupies intermediate positions. In some places the ore is observed to cross from one position to another on transverse, southwestward-dipping, obliquely striated fault planes that do not pass without the vein.

PRACTICAL CONCLUSIONS.

The results of structural study in the Cracker Creek district indicate that the "mother lode" is not notably displaced by transverse faults. Within the vein itself, however, there are faults which affect the ore bodies. Some of the smaller veins have been offset by faulting. The fact that the faults of known attitude are normal, and that in the movement upon them the horizontal component is commonly as important as the vertical one, should be taken into account in the development of such of the ore bodies as have been displaced.

SURVEY PUBLICATIONS ON GOLD AND SILVER.

The following list includes the more important publications by the United States Geological Survey, exclusive of those on Alaska, on precious metals and mining districts. Certain mining camps, while principally copper or lead producers, yield also smaller amounts of gold and silver. Publications on such districts are listed in the bibliographies for copper and for lead and zinc. When two metals are of importance in a particular district, references may be duplicated. For names of recent geologic folios in which gold and silver deposits are mapped and described, reference should be made to the table in the "Introduction" to this volume.

These publications, except those to which a price is affixed, may be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C.; the monographs from either the Director or the Superintendent of Documents.

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