CONTRIBUTIONS TO ECONOMIC GEOLOGY, 1905.

S. F. EMMONS, E. C. ECKEL, *Geologists in Charge.*

INTRODUCTION.

By C. W. HAYES, *Geologist in Charge of Geology.*

This bulletin is the fourth of a series, including Bulletins Nos. 213, 225, and 260, Contributions to Economic Geology for 1902, 1903, and 1904, 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. They are designed to meet the wants of the busy man, and are so condensed that he will be able to obtain results and conclusions with a minimum expenditure of time and energy. They also 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 reports.

In the first two bulletins of this series were 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 last year 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 No. 259. A similar segregation of papers relating to Alaska has been made this year.

In the preparation of the present volume promptness of publication has been made secondary only to the economic utility of the material presented. The papers included 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. A third class of papers was included in the bulletin for 1902—namely, abstracts of certain economic papers which had appeared in Survey publications during the year, chiefly such as gave a general account of the distribution and mode of occurrence of particular mineral deposits throughout the United States. Most of the publications on economic geology which have appeared during the past year were abstracted for advance publication in Bulletin 260, and it has therefore been unnecessary to abstract them in this volume.

The papers have been grouped according to the subjects treated. 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.

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, United States Geological Survey.*—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 of the United States Geological Survey.*—The bulletins of the Survey comprises a series of paper-covered octavo volumes, each containing usually a single report or paper. These bulletins, formerly sold at normal 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 therefore issued in the series of Professional Papers.

3. *Professional Papers of the United States Geological Survey.*—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 of the United States Geological Survey.*—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 of the United States Geological Survey.*—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 discriptions 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 occasionally 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 lists of these folios, showing the locations of the quadrangular 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 to date and the economic products discussed in the text of each, the products of greatest importance being printed in italic.

List of geologic folios, showing mineral resources described.

No.	Name of folio.	State.	Area in sq. m.	Author.	Mineral products described as occurring in area of folio.
1	Livingston	Mont	3,354	Iddings, J. P.; Weed, W. H.	Gold, copper, clays, lime stone, *coal*.
2	Ringgold	Ga.-Tenn	980	Hayes, C. W	*Coal*, *iron*, manganese, lime, clays, stone, road metal.
3	Placerville	Cal	932	Lindgren, W.; Turner, H. W.	*Gold*, copper, quicksilver chromite, stone.
4	Kingston	Tenn	969	Hayes, C. W	*Coal*, *iron*, lime, stone, road metal, clay.

List of geologic folios, showing mineral resources described—Continued.

No.	Name of folio.	State.	Area in sq. m.	Author.	Mineral products described as occurring in area of folio.
5	Sacramento	Cal	932	Lindgren, W	*Gold*, copper, chromite, iron, coal, stone, lime, clay.
6	Chattanooga	Tenn	975	Hayes, C. W	*Coal, iron*, lime, stone, road metal, clay.
7	Pikes Peak	Colo	932	Cross, W	*Gold.*
8	Sewanee	Tenn	975	Hayes, C. W	*Coal, iron*, lime, stone, road metal, clay.
9	Anthracite-Crested Butte.	Colo	465	Emmons, S. F.; Cross, W.; Eldridge, G. H.	*Coal, silver*, gold, stone, lime, clay.
10	Harpers Ferry	Va.-W. Va.-Md.	925	Keith, A	*Iron, ocher*, copper, stone, road metal, lime, cement rock.
11	Jackson	Cal	938	Turner, H. W	*Gold, copper*, chromite, iron, manganese, ocher, coal, stone, lime, clay.
12	Estillville	Va.-Ky.-Tenn.	957	Campbell, M. R	*Coal*, iron, marble, limestone.
13	Fredericksburg	Md.-Va	938	Darton, N. H	*Greensand marl*, stone, fuller's earth, clays, sand, gravel, *underground water*.
14	Staunton	Va.-W. Va	938	do	Iron, marble, lime, clay, coal.
15	Lassen Peak	Cal	3,634	Diller, J. S	Gold, infusorial earth lime, stone, coal.
16	Knoxville	Tenn.-N. C	969	Keith, A	*Marble*, slate, stone, gold, lime, cement, clay, water power.
17	Marysville	Cal	925	Lindgren, W.; Turner, H. W.	*Gold*, coal, gas, clay, lime, stone, water.
18	Smartsville	do	925	do	*Gold*, copper, quicksilver iron, lime, brick clay stone.
19	Stevenson	Ga.-Ala.-Tenn.	980	Hayes, C. W	*Coal, iron*, lime, stone, road metal, clay.
20	Cleveland	Tenn	975	do	*Iron*, lead, lime, stone, clay
21	Pikeville	do	969	do	*Coal*, iron, stone, clay.
22	McMinnville	do	969	do	*Coal*, iron, stone, clay.
23	Nomini	Md.-Va	938	Darton, N. H	*Greensand marl*, fuller's earth, clay, stone, sand, gravel, *underground water*.
24	Three Forks	Mont	3,354	Peale, A. C	*Gold*, silver, copper, iron, coal, lime, clay, pumice, *mineral water*.
25	Loudon	Tenn	969	Keith, A	*Coal*, marble, lime, stone, clay, iron, slate.
26	Pocahontas	Va.-W. Va	950	Campbell, M. R	*Coal*, lime, stone, clay, marble.
27	Morristown	Tenn	963	Keith, A	*Marble, stone*, lead, zinc, lime, cement, clay, water.
28	Piedmont	Md.-W. Va	925	Darton, N. H.; Taff, J. A.	*Coal*, iron, lime, stone, road metal, clay.
29	Nevada City special.	Cal	35	Lindgren, W	*Gold.*
30	Yellowstone National Park.	Wyo	3,412	Hague, A.; Weed, W. H.; Iddings, J. P.	National Park; no mining permitted.
31	Pyramid Peak	Cal	932	Lindgren, W	*Gold.*
32	Franklin	Va.-W. Va	932	Darton, N. H	*Iron*, coal, manganese, lime, stone, road metal, clay.
33	Briceville	Tenn	963	Keith, A	*Coal, iron*, lead, marble, lime, stone, clay.
34	Buckhannon	W. Va	932	Taff, J. A.; Brooks, A. H.	*Coal*, lime, stone, clay.

List of geologic folios, showing mineral resources described—Continued.

No.	Name of folio.	State.	Area in sq. m.	Author.	Mineral products described as occurring in area of folio.
35	Gadsden	Ala.	986	Hayes, C. W	*Coal*, *iron*, lime, stone.
36	Pueblo	Colo	938	Gilbert, G. K	*Stone*, *gypsum*, clay, iron *underground water*.
37	Downieville	Cal	919	Turner, H. W	*Gold*, iron, chromite, lime marble.
38	Butte special	Mont	23	Weed, W. H.; Emmons, S. F.; Tower, G. W.	*Copper*, *silver*, gold.
39	Truckee	Cal	925	Lindgren, W	*Gold*, silver, coal, stone mineral water.
40	Wartburg	Tenn	963	Keith, A	*Coal*, *oil*, iron, lime, clay.
41	Sonora	Cal	944	Turner, H. W.; Ransome, F. L.	*Gold*, quicksilver, copper, chromite, lime, stone.
42	Nueces	Tex	1,035	Hill, R. T.; Vaughan, T. W.	Stone, gravel, *underground water*.
43	Bidwell Bar	Cal	919	Turner, H. W	*Gold*, manganese, iron, chromite, stone.
44	Tazewell	Va.-W. Va	950	Campbell, M. R	*Coal*, iron, barite.
45	Boise	Idaho	864	Lindgren, W	*Gold*, silver, coal, diatomaceous earth, stone, clay, underground water.
46	Richmond	Ky	944	Campbell, M. R	Coal, fluorite, phosphate clay, stone, road metal.
47	London	do	950	do	*Coal*, stone.
48	Tenmile district special	Colo	62	Emmons, S. F	*Silver*.
49	Roseburg	Oreg	871	Diller, J. S	Gold, copper, quicksilver, coal, clay, stone.
50	Holyoke	Mass.-Conn	885	Emerson, B. K	Granite, emery, chromite, quartz, road material, sandstone, clay.
51	Big Trees	Cal	938	Turner, H. W.; Ransome, F. L.	*Gold*, silver.
52	Absaroka	Wyo	1,706	Hague, A	Silver.
53	Standingstone	Tenn	963	Campbell, M. R	*Coal*, oil, lime, clay.
54	Tacoma	Wash	812	Willis, B.; Smith, G. O.	*Coal*, *stone*, clay.
55	Fort Benton	Mont	3,234	Weed, W. H	Gold, *silver*, lead, iron, gypsum, *coal*, stone, underground water.
56	Little Belt Mountains.	do	3,295	do	*Coal*, *silver*, lead, copper, iron, *sapphires*, mineral water.
57	Telluride	Colo	236	Cross, W.; Purington, C. W.	*Gold*, *silver*.
58	Elmoro	do	950	Hills, R. C	*Coal*, stone, *underground water*.
59	Bristol	Va.-Tenn	957	Campbell, M. R	*Coal*, iron, zinc, barite, marble, clay.
60	La Plata	Colo	237	Cross, W.; Spencer, A. C.; Purington C. W.	*Gold*, *silver*, coal.
61	Monterey	Va.-W. Va	938	Darton, N. H	Iron, stone, clay, road metal.
62	Menominee special.	Mich	125	Van Hise, C. R.; Bayley, W. S.	*Iron*.
63	Mother Lode district.	Cal	428	Ransome, F. L	*Gold*, silver, manganese quicksilver, stone.
64	Uvalde	Tex	1,040	Vaughan, T. W	*Asphalt*, gold, silver, iron, coal, underground water
65	Tintic special	Utah	229	Tower, G. W.; Smith, G. O.; Emmons, S. F.	*Gold*, *silver*, *lead*, *copper*.
66	Colfax	Cal	925	Lindgren, W	*Gold*, stone, clay, water.
67	Danville	Ill.-Ind	228	Campbell, M. R; Leverett, F.	*Coal*, clay, gravel, underground water.

List of geologic folios, showing mineral resources described—Continued.

No.	Name of folio.	State.	Area in sq. m.	Author.	Mineral products described as occurring in area of folio.
68	Walsenburg	Colo	944	Hills, R. C	*Coal*, stone, clay, *underground water*.
69	Huntington	W. Va.-Ohio	938	Campbell, M. R	*Coal*.
70	Washington	D. C.-Va.-Md.	465	Darton, N. H.; Keith, A.	Gold, iron, clay, stone, road materials, greensand marls, *underground water*.
71	Spanish Peaks	Colo	950	Hills, R. C	*Coal*, stone, gold, silver, *underground water*.
72	Charleston	W. Va	938	Campbell, M. R	*Coal, salt, oil, gas*, iron.
73	Coos Bay	Oreg	871	Diller, J. S	*Coal*, gold, stone.
74	Coalgate	Ind. T	980	Taff, J. A	*Coal*, stone, clay.
75	Maynardville	Tenn	963	Keith, A	*Marble*, coal, stone, lead, zinc, lime, road materials, clay.
76	Austin	Tex	1,030	Hill, R. T.; Vaughan, T. W.	Oil, stone, lime, clay, cement rock, underground water.
77	Raleigh	W. Va	944	Campbell, M. R	*Coal*.
78	Rome	Ga.-Ala	986	Hayes, C. W	*Bauxite, iron, slate*, lime.
79	Atoka	Ind. T	986	Taff, J. A	*Coal*, stone, clay.
80	Norfolk	Va.-N. C	1,913	Darton, N. H	Sand, clay, *underground water*.
81	Chicago	Ill.-Ind	892	Alden, W. C	*Stone*, clay, molding sand, water.
82	Masontown-Uniontown.	Pa	458	Campbell, M. R	*Coal, oil, clay*, stone, glass sand, iron.
83	New York City	N. Y.-N. J	906	Merrill, F. J. H.; Hollick, A.; Darton, N. H.; Willis, B.; Salisbury, R. D.; Dodge, R. E.; Pressey, H. A.	*Marble*, granite, *road material*, clay, iron, water.
84	Ditney	Ind	938	Fuller, M. L.; Ashley, G. H.	*Coal*, gas, clay, stone, iron.
85	Oelrichs	S. Dak.-Nebr.	871	Darton, N. H	Stone, gypsum, lime, volcanic ash, *underground water*.
86	Ellensburg	Wash	820	Smith, G. O	Building stone, road metal, *ground water, underground water*.
87	Camp Clarke	Nebr	892	Darton, N. H	Volcanic ash.
88	Scotts Bluff	do	892	do	Do.
89	Port Orford	Oreg	878	Diller, J. S	*Coal*, gold, platinum.
90	Cranberry	Tenn	963	Keith, A	Mica, gold, brick clay, *iron ore*.
91	Hartville	Wyo	885	Smith, W. S. T	*Iron ore*, copper, lime, building stone, gypsum, fire clay.
92	Gaines	Pa.-N. Y	223	Fuller, M. L.; Alden, W. C.	*Oil*, coal.
93	Elkland-Tioga	Pa	445	do	Flagstone, lime, gravels.
94	Brownsville-Connellsville.	do	457	Campbell, M. R	*Coal, natural gas*.
95	Columbia	Tenn	969	Hayes, C. W.; Ulrich, E. O.	*Phosphate*, iron.
96	Olivet	S. Dak		Todd, J. E	Granite, lime, quartzite, underground water.
97	Parker	do	871	do	Quartzite, chalk, cement rock, underground water.
98	Tishomingo	Ind. T	986	Taff, J. A	Granite, lime building stone, clay.
99	Mitchell	S. Dak	863	Todd, J. E	*Underground water*, sandstone, chalkstone.
100	Alexandria	do	863	Todd, J. E.; Hall, C. M.	*Underground water*, quartzite, sandstone, chalkstone.

List of geologic folios, showing mineral resources described—Continued.

No.	Name of folio.	State.	Area in sq. m.	Author.	Mineral products described as occurring in area of folio.
101	San Luis	Cal	975	Fairbanks, H. W	*Bituminous rock*, building stone, road metal, chrome iron, hematite, manganese, pumice, infusorial earth.
102	Indiana	Pa	237	Richardson, G. B	*Coal*, *gas*, *fire clay*, brick clay, building stone.
103	Nampa	Idaho		Lindgren, W.; Drake, N. F.	Gold, coal, *opals*, building stone.
104	Silver City	do	871	do	*Gold*, *silver*, coal, opals.
105	Patoka	Ind.-Ill	938	Fuller, M. L.; Clapp, F. G.	Coal, gas, oil, asphalt, fire clay, brick clay, building stone, gravel.
106	Mount Stuart	Wash	805	Smith, G. O	*Gold*, copper, silver, nickel, quicksilver, *coal*, stone, road metal.
107	Newcastle	Wyo.-S. Dak	864	Darton, N. H	*Coal*, petroleum, *gypsum*, bentonite, salt brines, stone, underground water.
108	Edgemont	Nebr.-S. Dak.	871	Darton, N. H.; Smith, W. S. T.	Water supply, coal, gypsum, stone, grindstones, underground water.
109	Cottonwood Falls	Kans	938	Prosser, C. S.; Beede, J. W.	Building stone, clay, road metal.
110	Latrobe	Pa	228	Campbell, M. R	*Coal*, natural gas, building stone, *glass sand*, paving blocks, ballast, lime, salt, *fire clay*.
111	Globe	Ariz	249	Ransome, F. L	*Gold*, *silver*, *copper*, lead, lime, building stone, *underground water*.
112	Bisbee	do	170	do	*Copper*, gold, lead, clay, silica, building stone, *underground water*.
113	Huron	S. Dak	857	Todd, J. E	Building stone, clay, sand, gravel, *underground water*.
114	De Smet	do	857	Todd, J. E.; Hall, C. M.	Clay, sand, gravel, underground water.
115	Kittanning	Pa	226	Butts, C.; Leverett, F.	*Coal*, *oil*, *gas*, *clay*, lime, iron, building stone, sand.
116	Asheville	N. C.-Tenn	969	Keith, A	*Talc*, soapstone, *barite*, corundum, garnet, magnetite, iron, marble.
117	Casselton-Fargo	N. Dak.-Minn.	1,640	Hall, C. M.; Willard, D. E.	*Underground water*.
118	Greeneville	Tenn.-N. C	963	Keith, A	*Marble*, building stone, road metal, iron, lime, brick clay.
119	Fayetteville	Mo.-Ark	963	Adams, G. I.; Ulrich, E. O.	Clay, building stone, lime, coal.
120	Silverton	Colo	236	Cross, W.; Howe, E.; Ransome, F. L.	*Gold*, *silver*, *copper*, *lead*, zinc, iron, lime, building stone.
121	Waynesburg	Pa	229	Stone, R. W	*Coal*, *gas*, *oil*, building stone, lime, clay, iron, underground water.
122	Tahlequah	Ind. T.-Ark	969	Taff, J. A	Building stone, lime, clay.
123	Elders Ridge	Pa	227	Stone, R. W	*Coal*, *gas*, oil, building stone, lime, fire clay, stoneware clay.
124	Mount Mitchell	N. C	969	Keith, A	Soapstone, *talc*, mica, precious stones, corundum, graphite, iron, chromite, *building stone*, lime, brick clay.
125	Rural Valley	Pa	226	Butts, C	*Coal*, oil, *gas*, fire clay, iron ore, lime sandstone.

List of geologic folios, showing mineral resources described—Continued.

No.	Name of folio.	State.	Area in sq. m.	Author.	Mineral products described as occurring in area of folio.
126	Bradshaw Mountains.	Ariz.	986	Jagger, T. A., jr.; Palache, C.	*Gold*, *silver*, copper, iron, building stone, onyx marble.
127	Sundance	Wyo.-S. Dak.	857	Darton, N. H.	Gold, *tin*, silver, lead, *coal*, gypsum, bentonite, *underground water*.
128	Aladdin	Wyo.-S. Dak.-Mont.	894	Darton, N. H.; O'Harra, C. C.	*Underground water*, coal, gypsum, lime.
129	Clifton	Ariz.	250	Lindgren, W.	*Copper*, iron, lead, gold, kaolin.
130	Rico	Colo.	236	Cross, W.; Spencer, A. C.; Ransome, F. L.	*Gold*, *silver*, zinc, lead, building stone, lime.
131	Needle Mountains	Colo.	236	Cross, W.; Howe, E.; Irving, J. D.; Emmons, W. H.	Gold, silver.
132	Muscogee	Ind. T.	969	Taff, J. A.	Oil, *coal*.
133	Ebensburg	Pa.	228	Butts, C.	*Coal*, clay, shale, building stone, underground water.
134	Beaver	Pa.	227	Woolsey, L. H.	*Clay*, coal, *oil*, gas, building stone.
135	Nepesta	Colo.	938	Fisher, C. A.	Cement, iron ore, oil, gas, gravel.

6. *Mineral Resources of the United States.*—From 1883 to 1894, inclusive, an octavo cloth-bound volume bearing the above title was issued annually, except that the reports for the years 1883–84 and 1889–90 were included by pairs in single volumes. The first of this series was Mineral Resources of the United States, 1882; the last, Mineral Resources of the United States, 1893. In 1894 this form of publication was discontinued, in accordance with an act of Congress, and the statistical material was included in certain parts of the sixteenth, seventeenth, eighteenth, nineteenth, twentieth, and twenty-first annual reports. The separate publication of the series on mineral resources was resumed, however, in 1901, in accordance with an act of Congress, and five volumes of the new series, Mineral Resources of the United States for 1900, for 1901, for 1902, for 1903, and for 1904 have been issued.

This publication contains a systematic statement of the production and value of the mineral products of the United States, a summary of new mineral resources developed, and occasional short papers on economic geology when these are necessary to account for the new developments.

INVESTIGATION OF METALLIFEROUS ORES.

By S. F. Emmons, *Geologist in Charge.*

ECONOMIC PUBLICATIONS OF THE YEAR.

During the year the number of Survey publications on subjects connected with the investigation of metalliferous ores within the United States proper was somewhat smaller than during previous years. This has resulted less from the falling off of the amount of work done in that line by members of the Survey than from other causes, among which should be mentioned, first, the fact that several economic geologists have resigned from the Survey to accept more remunerative positions elsewhere, which has so far reduced the available force; second, the administrative investigations intended to improve the service of the Government Printing Office, but whose immediate effect has been to delay temporarily the printing of the Survey reports. The following publications on metalliferous investigations have been issued during the year 1905:

Professional Papers:

No. 36. Lead, zinc, and fluorspar of western Kentucky, by E. O. Ulrich and W. S. Tangier-Smith.

No. 38. Economic geology of the Bingham mining district, Utah, by J. M. Boutwell, Arthur Keith, and S. F. Emmons.

No. 42. Geology of the Tonopah mining district, Nevada, by J. E. Spurr.

No. 43. Copper deposits of Clifton-Morenci district, Arizona, by Waldemar Lindgren.

Bulletins:

No. 246. Zinc and lead deposits of northwestern Illinois, by H. F. Bain.

No. 253. Fluorspar deposits of southern Illinois, by H. F. Bain.

No. 267. Copper deposits of Missouri, by H. F. Bain and E. O. Ulrich.

Folios:

No. 120. Silverton quadrangle, Colorado, by Whitman Cross, Ernest Howe, and F. L. Ransome.

No. 126. Bradshaw Mountains quadrangle, Arizona, by T. A. Jaggar, jr., and Charles Palache.

No. 129. Clifton quadrangle, Arizona, by Waldemar Lindgren.

Unpublished studies.—(1) Studies of which the field and office work have been entirely completed and the reports written by the authors, in different stages of completion for final publication:

Professional papers:

The geology and gold deposits of the Cripple Creek district, Colorado, by Waldemar Lindgren and F. L. Ransome.

Ore deposits of the Silver Peak quadrangle, Nevada, by J. E. Spurr and G. H. Garrey.

Ore deposits of the Cœur d'Alene district, Idaho, by F. L. Ransome and F. C. Calkins.

Copper deposits of the Appalachian region, by W. H. Weed.

Bulletin:

Reconnaissance of some gold and tin deposits of the Southern Appalachians, by L. C. Graton, with notes on the Dahlonega mines, by Waldemar Lindgren.

(2) Studies for which the field work has been completed and whose manuscript is in more or less advanced stages of completion by the authors:

Ore deposits of the Georgetown mining district of Colorado, by J. E. Spurr and G. H. Garrey.

Economic geology of the Park City mining district of Utah, by J. M. Boutwell.

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

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

Advance notices of most of the above reports have already appeared in previous numbers of the Economic Bulletin in the form either of abstracts or of preliminary reports on the results of the field work. Where this has not been done, or where the final publication of the report has been long delayed, there has been some good reason therefor which may not always be apparent to the public.

The survey of the Park City mining district has disclosed unexpected structural complications in the geology which promise to have an important influence on the mining development of the region and demand a correspondingly great amount of care and detail in their working out. Other duties to which he has from time to time been assigned have, furthermore, taken a certain amount of Mr. Boutwell's time from this work. That he might push it to completion with the shortest possible delay, Mr. Boutwell undertook no field work whatever during the past year, but spent the entire summer in office work on this report, which it is expected will be completed before the opening of another field season.

For a number of years past there has been in preparation a detailed study of the complicated vein systems of the copper district of Butte, which will constitute the most important record yet made of the manner of formation of copper in veins in granite, their subsequent faulting by a new system of secondary veins, and the sulphide enrichment of both systems by descending waters. This record is of relatively small importance to the immediate development of the district, its greatest value being to the mining world in general as an illustration of the typical development of this important class of copper deposits. Completeness of the record has, therefore, been of more importance than early publication, especially as, pending the settlement of the many lawsuits in regard to property rights in the district, the Survey report might exercise an unfavorable influence on one side or another on the questions at issue; hence Mr. Weed's work on this report has been put aside from time to time to admit of his carrying on other investigations whose publication seems of more immediate importance to the mining public. In view of the recent important underground discoveries at Butte, this delay has proved to be most wise, since it will have rendered the record far more complete than it could otherwise have been. It is intended, however, that the report shall now be prepared for the earliest possible publication.

In the case of the resurvey of the Leadville district, whose long delay has not unnaturally been the cause of some unfavorable comment, the conditions governing its publication are more difficult to explain, especially to those who are not practically familiar with the actual mining work and manner of occurrence of ore in the district and with the peculiar methods which consequently have to be pursued in making a geological map there. The ordinary method of making a geological map of a given area is to carefully examine its surface and enter on the map the outlines of the different rock formations, with their dips and strikes, supplementing this with what data may be obtained from the underground workings of the mines or their artificial excavations. Thus, in order to depict the underground structure, the surface outcrops are, so to speak, projected downward. In the Leadville district, however, practically no information is derived from the surface, and the geological outlines represented on the surface map must be made by projecting upward to the surface the information obtained in studying the underground workings of the mines. This, although more laborious, is a very practicable method, provided only that the underground workings extend nearly continuously over the whole area. This is unfortunately not the case at Leadville, for although in certain portions, where the ore bodies are concentrated, mine drifts honeycomb the rocks in all directions, there are considerable areas where ore has not been found or which are practically unexplored underground. Even in the explored areas there are gaps in possible information where extensive mines have been abandoned and their drifts have become inaccessible, with regard to which no accurate geological data can, therefore, be obtained. With each new mining development portions of these gaps are filled up, and when the mines are visited while still open and accessible the information gathered adds to that already obtained with regard to the actual underground structure of the district. Thus, since starting the review of the Leadville work in 1890, the writer has made visits to the region every year or two to gather such new data, but causes beyond his control have rendered it impossible for him to have compiled at any given period the material already gathered in form for publication. These recent studies have shown that the broad outlines of geological structure, as given on the original maps of the region, are substantially correct. The modifications of them that the new data will necessitate are such as no human foresight could have predicated, consisting mainly of faults and intrusive sheets of which no indication could be seen at the surface or in the underground workings then accessible. On these early maps much of the underground structure shown was necessarily inference and some pure surmise. On the new maps it is desired to restrict the area of inference and surmise as much as possible. Inasmuch as the manner of occurrence of the ore is thoroughly understood by Leadville miners, the principal value of the present review will be to afford a picture of the ground already opened and it can not be expected to show very much that is new with regard to ground that has not been opened; hence, while the work has not been intentionally delayed, the delay that has occurred has added greatly to its value. It can, in the nature of things, be of little use in determining the position of undiscovered ore bodies, but it may afford means of estimating more nearly the area of possible extension of ore-bearing horizons in some parts of the region, such as those that are buried beneath several hundred feet of wash. It is the present intention of the writer to publish smaller preliminary maps of such areas as can be prepared without waiting till the accumulated data are sufficient for the accurate reconstruction of the map of the entire district.

ECONOMIC WORK IN PROGRESS DURING THE YEAR.

GENERAL DISCUSSION.

An important step has been taken during the year toward rendering the economic work of the Survey more comprehensive and efficient by instituting a closer cooperation between the section of metalliferous ores and the division of mineral statistics. To this end, early in the year, the supervision of the collection of statistics of the precious metals was placed in charge of Mr. Waldemar Lindgren, of the former section, who thus assumed, besides his regular work, a very considerable addition of labor in reorganizing and improving the method of collection hitherto pursued. Some of the shortcomings in the previous method have been pointed out in a former number of this bulletin. The amelioration that can be expected from the supervision of the work by a man like Mr. Lindgren, who combines long experience in all the details of the precious-metal industry with a profound knowledge of the geological relations of their deposits, will be important, even more than in furnishing accurate statistics of the total production of the country, for segregating the proportions of that production, not only among States and counties but among districts, and in furnishing at the same time sufficient geological data with regard to the less known districts to render possible an annual discussion of the precious-metal industry with reference to its geological distribution. But of more immediate importance to those actively interested in mining will be the fact that with regard to individual mining districts, especially those that are new or little known, the investor in mines can feel sure that the information furnished is given by men who are not only competent to speak with authority from a technical point of view but that what they say is wholly unbiased and free from even the suspicion of any personal interest that might make them consciously or unconsciously regard the future in too favorable a light.

The beneficial results of this change in method can not be fully appreciated until the mineral statistics for the year 1905 shall have been published, but an improvement is already noticeable in those for the year 1904, in which, although the actual figures had been collected before he took charge, Mr. Lindgren was enabled to introduce decided improvements in the methods of presentation of facts and their discussion.

When this method of treating statistics shall have been extended to the other metals the discussion of the results from the geological standpoint will form an important part of the work of the section of metalliferous ores.

The work more strictly belonging to this section (excluding that in Alaska) that has been carried on during the year will be noted in geographic order:

UNITED STATES IN GENERAL.

Mr. W. H. Weed has compiled from certain publications a general review of the important copper deposits of the United States which will, it is thought, be found of value to all interested in mines as furnishing in condensed form the geological data necessary for an understanding of the manner of occurrence of the principal copper-producing ores.

APPALACHIAN REGION.

Mr. Weed has continued from time to time during the year his reconnaissance studies of the copper deposits of the Appalachian region, the manuscript of which, as already noted, is very nearly ready for publication, and it is hoped that it will be issued very shortly after the appearance of the present bulletin.

Mr. Spencer has carried on during the summer a special study of the geological relations of the magnetite deposits of the Franklin Furnace quadrangle, in New Jersey, with the idea that the solution of this problem may throw important light on the mooted question of the origin of the Franklin Furnace zinc ores.

Mr. Charles Palache has been occupied during the same time in making a mineralogical study of the Franklin Furnace ores, which it is hoped will also throw some light on their genesis.

MISSISSIPPI VALLEY REGION.

At the commencement of the field season Mr. Bain, who has hitherto had charge of the work in this region, resigned his position on the Survey to accept the directorship of the Illinois State Geological Survey; consequently, no economic field work has been carried on in this region during the year.

As reconnaissance examinations, in intervals of other work, Mr. E. O. Ulrich has examined the copper deposits in sedimentary rocks that are of widespread occurrence in northern Texas. Mr. G. B. Richardson has also studied the geological relations of the tin deposits of the Franklin Mountains, near El Paso, the results of which appear in this bulletin.

ROCKY MOUNTAIN REGION.

Arizona.—The work planned for Arizona for the field season had been an economic survey of the Tombstone mining district and reconnaissance examinations of the smaller mining districts of the Territory by Mr. F. L. Ransome and his assistants. When, however, at the commencement of the field season, Mr. Spurr resigned his position on the Survey, it was judged best to assign Mr. Ransome to the economic survey of the Goldfield and Bullfrog districts of Nevada, which originally had been allotted to Mr. Spurr; hence, the field work that has been done in Arizona during the year has consisted only of visits by the writer to the Tombstone, Bisbee, and Globe districts for the purpose of keeping in touch with geological phenomena newly exposed in these regions by recent mining developments.

Colorado.—In Colorado a geological field party has been engaged during the summer in mapping more carefully the geology of portions of northwestern Colorado, which will be opened by the new "Moffatt road" that is destined to connect Denver with Salt Lake City. In the course of this work, Mr. H. S. Gale was enabled to make a reconnaissance examination of the Hahns Peak gold field and map its geology. His report on this district is included in the present volume.

In continuation of the work already commenced in Clear Creek and Gilpin counties, Mr. Spurr was able to spend ten days, and his assistant, Mr. G. H. Garrey, spent six weeks in studying the mines in the vicinity of Idaho Springs. A preliminary report by Mr. Garrey on the results of this work will be found later in this volume.

In western Colorado, as part of a reconnaissance made of the region south of the La Sal Mountains by Mr. Cross's party, Mr. W. H. Emmons examined some interesting copper deposits in veins traversing Mesozoic rocks, and contributes a report thereon to the present volume. The same geologist presents an abstract of his report on the mines of the Needle Mountain quadrangle, in the southern San Juan Mountains.

Idaho.—In Idaho considerable reconnaissance work has been done in the region both to the north and to the south of the Cœur d'Alene district, the field work of which was completed by Mr. Ransome and his assistants during the field season of 1904.

Mr. D. F. MacDonald, former assistant of Mr. Ransome, made an extensive geological reconnaissance of the country stretching for a hundred miles north of the Cœur d'Alene, including portions of northern Idaho and northwestern Montana, and submits in the present volume a report on his observations with special reference to their economic bearing.

Mr. Collier, who was for several years previous engaged in geological work in the Alaskan division, also submits a report on the metallic resources of the region immediately adjoining the Cœur d'Alene district on the south.

Montana.—Late in the year Mr. Weed made a visit to Butte, Mont., to study the important new developments recently made in the copper veins of this great district, which thus completes his record for the exhaustive report which he is preparing on its copper deposits.

Nevada.—The attention of the mining public has been for the past few years especially directed to Nevada because of the unusually rich gold ores found in the newly discovered districts, such as Tonopah, Goldfield, Bullfrog, and others. A proportionately larger portion of the economic work of the Survey has, therefore, been done in this State to meet the demand for information with regard to its geological structure. Special topographic maps had already been prepared of the Goldfield and Bullfrog districts, and Mr. Spurr, who had made the survey of the Tonopah district, was originally assigned to the economic examinations of these districts. After Mr. Spurr's resignation from the Survey Mr. Ransome took charge of the work, having as assistants Mr. G. H. Garrey, who had previously been working with Mr. Spurr, and Mr. W. H. Emmons. He was, however, unable to take the field until September, and owing to delays incident on the unexpected difficulty of the work and the unusually severe winter weather the field work, which has been made to include also a reconnaissance of the Searchlight district, is only just completed—too late to admit of the preparation of any preliminary report for this volume.

During the past field season a party under Mr. R. H. Chapman has been engaged in making a topographical survey of the portions of the Great Basin region in southern Nevada and eastern California that include the new mining developments. To this party Mr. S. H. Ball was attached, as geologist, to make such geological surveys of the region as was possible during the relatively rapid movements of the topographic party. In the course of this work he was enabled to visit a number of smaller mining districts and note their geological structure and such facts with regard to their ore deposits as could be ascertained at the present stage of their development. His notes on these districts, although the geological information they afford is necessarily somewhat meager, are published in this volume, in response to the popular demand for early information with regard to new districts. It must be borne in mind, however, by those who have made these demands, that the geologist can not see any farther into a rock than any other man; he can only draw inferences from what is exposed to view, and the deeper the exposure the greater its value for such inferences, since surface alteration of the rocks so obscures their true character as to render their determination very uncertain. As this surface alteration often extends for a considerable depth below the actual surface, it is only when he can extend his studies to a depth that is beyond the reach of surface alteration that the geologist can determine the true character of the rocks with sufficient certainty to render his inferences of permanent value.

Zinc mines are of rather exceptional occurrence in Nevada, and this fact adds interest to the report of Mr. Bain, to be found on later pages of the present volume, on the Potosi mine, in which he finds certain analogies with the zinc deposits of the Mississippi Valley region.

New Mexico.—The Territory of New Mexico is rich in mineral deposits, but as yet no great mining districts comparable to Butte and Cripple Creek have been developed within its boundaries and no detailed economic studies have hitherto been made there by the Survey. It has, however, a great number of smaller mining districts of geological interest and of considerable economic importance.

During the past summer reconnaissance examinations of all these districts have been made in as much detail as the want of actual topographic surveys will admit. This work has been under the charge of Mr. Waldemar Lindgren, who has been assisted by Messrs. L. C. Graton and C. H. Gordon. A preliminary report of the results of their work has been prepared for this volume.

Texas.—The Franklin Mountains, just north of El Paso, though within the political boundaries of Texas, belong more properly to the physiographic province of New Mexico. The occurrence of tin ores in these mountains has long been known and a short description of them by Mr. W. H. Weed was published in Bulletin No. 178. During the past summer Mr. G. B. Richardson made a reconnaissance examination of the geology of the entire range and incidentally reexamined the tin deposits. His report is to be found on later pages of this bulletin.

Utah.—No systematic economic field work has been done in the State of Utah during the present season. A special survey of the region around Frisco, in the southern part of the State, including the Horn Silver, Cactus, and other mines, had been planned and the topographic basis for the same was already prepared; but, owing to the reduction in the number of available economic geologists, there was no one to carry on the work and it has therefore been postponed until another season.

Mr. Lindgren visited the State in the interest of his work on statistics of the precious metals and incidentally made an examination of the Annie Laurie gold mine, in the vicinity of Marysvale, in the southern part of the State. His report, which appears later in this volume, will be of interest as the description of an important gold mine in a district of whose geology little has hitherto been known.

INVESTIGATION OF IRON ORES AND NONMETALLIFEROUS MINERALS.

By Edwin C. Eckel, *Geologist in Charge.*

INTRODUCTION.

The work which can be carried on by the Survey in the investigation of iron ores and the nonmetallic products differs very markedly from that which is either required or practicable in the examination of gold, silver, copper, lead, and zinc deposits. The differences between the two lines of work are based on fundamental differences between the products treated. In the one case we have usually to deal with small bodies of ore of high unit value occurring at scattered localities and requiring little else than mining to make it a valuable product. In dealing with iron ores and the nonmetals, on the other hand, we encounter minerals of low unit value, widely distributed over the country and usually occurring in large bodies, whose industrial value depends chiefly on nongeologic factors, such as composition, transportation, facilities, milling methods, etc.

These facts have influenced the work of the Survey in dealing with iron and the nonmetals in two ways. First, a proper report on such products requires very careful detailed stratigraphic and areal work and can hardly be undertaken profitably unless a satisfactory topographic base is available. Second, the products owe so much of their possible value to purely technologic and industrial conditions that a complete report on them requires consideration of many subjects not directly connected with the geology of the deposits. For this reason Survey reports on the iron ores, fuels, structural materials, etc., must necessarily contain matter relative to the industrial relations of these products, which is not necessary in reporting, for example, on a deposit of high-grade gold ore. The economic work, furthermore, must generally be carried on in close connection with detailed areal and stratigraphic examinations; and for the best results a very accurate topographic base is essential.

A further essential difference between the work possible on the two classes of products lies in the fact that, in general, the geologist can point out, in advance of actual exploration, where workable deposits of limestone, clay, coal, and iron ore are likely to occur. Furthermore, in many cases he can make a close estimate of the total tonnage available in any area—an estimate which would be impossible in dealing with gold, copper ores, etc. It is probable, for example, that a careful geological examination of a southern red-hematite district would enable the geologist to estimate the total quantity of ore with a limiting error of less than 10 per cent, and this is a grade of accuracy very different from that possible in dealing with the irregular bodies in which the ores of gold, silver, copper, lead, and zinc usually occur.

IRON, MANGANESE, AND ALUMINUM ORES.

Iron ores.—For many years past the Lake Superior district has furnished two-thirds of the iron ore produced in the United States. The geologic problems connected with these ore deposits are of great complexity, and the importance of the subject naturally caused this to be the first iron-ore district to be taken up in a detailed way by the Survey. A series of reports on the various lake ore ranges have been published, and as the detailed mapping of that district is now practically completed work is being commenced on the iron-ore deposits of the Southern and Western States.

Several Survey parties were engaged in the examination of Alabama iron districts during 1905. Mr. Butts, with the assistance of Mr. Dawson, completed areal and economic mapping of a large part of the important Birmingham district and collected data on the "Clinton" red ores of that region. Mr. E. C. Eckel examined the red-ore deposits in the Lookout Mountain district from Chattanooga to Attalla, Gadsden, and Gaylesville, and later visited the brown-ore districts, of which Anniston is the center. Arrangements have been made for cooperative work with the Alabama Geological Survey, and reports on the iron ores and iron industries of Alabama will be issued as soon as possible. The present bulletin contains a brief preliminary report on the red ores of the Lookout Mountain district.

In Virginia work on the iron ores was carried on in cooperation with the Virginia Geological Survey, the field work being divided between the two organizations. Mr. R. J. Holden, of the Virginia Survey, examined the brown ores of the New River-Cripple Creek district and later spent some time in the Oriskany district. Mr. E. C. Eckel examined most of the Oriskany and Clinton ores of the State, with the assistance of Mr. J. S. Grasty. Prof. H. D. Campbell placed his detailed maps of the district at our disposal, which rendered possible a very complete report on the district. In this bulletin (pp. 183 and 190) preliminary reports on several Virginia iron districts are presented.

A brief paper on the ores of Bath County, Ky., is included, the report being based on data obtained by Messrs. Kindle and Phalen in the course of areal mapping in that district.

The recent extension of actual development as well as of detailed exploration of the new ore deposits of the Rocky Mountain and Pacific States has made it evident that these deposits may prove to be important factors in the iron industry of the future. Mr. C. K. Leith examined most of the developed districts during the past year, and his report, presented later in this bulletin, is a valuable preliminary statement on the subject. Detailed work on these iron ores will be taken up by the Survey as soon as possible.

Mr. A. C. Spencer has for some time been engaged in a very detailed study of the iron, zinc, and manganese deposits of the Franklin Furnace district of New Jersey. In connection with this work he has examined a number of magnetite deposits elsewhere in New Jersey and in New York, and has formulated theories of occurrence and origin which seem to have an important bearing on the future development of these ores. The exploratory work so far carried on by mining companies has been of a rather haphazard nature, based on no definite working theory. It is hoped that the publication, during 1906, of Mr. Spencer's report will supply the prospector and miner with data which will serve as a guide both in locating and valuing the deposits.

Manganese.—As most of the manganese ores of the United States are closely associated, both geographically and geologically, with brown-iron ores, work on the two products is best carried on by the same Survey parties. In the course of the work on the southern iron ores outlined on a previous page considerable data have been collected concerning the manganese ores of Virginia, Georgia, and Alabama.

Aluminum.—During 1905 bauxite was discovered in Tennessee, Virginia, and Pennsylvania, far to the north of the previously known occurrences. Developments in the use of low-grade bauxite for the manufacture of refractory brick have also stimulated interest in the industry, so that prospecting for bauxite has been particularly active during the past year. It is noteworthy, however, that though these new discoveries extended the area known to contain bauxite deposits, the general location and character of the deposits are entirely in line with the conditions pointed out by Survey geologists a decade ago. During 1905 the Arkansas deposits were reexamined by Survey parties, and it is probable that in 1906 the new eastern districts will be surveyed and reported on.

FUELS AND OTHER HYDROCARBONS.

The great activity in the investgation of the fuel resources of the country which was noted in "Contributions to Economic Geology" for 1904 was continued and considerably extended during the season of 1905. This extension was due in large measure to the general interest which was taken in the investigations carried on by the fuel-testing division and to a large amount of geologic work in the coal fields of the country, which was made possible by an increase in appropriations.

Coal.—To coordinate the geologic work in various parts of the country, Mr. M. R. Campbell was directed to exercise supervision over the investigations of coal resources throughout the United States. Although Mr. Campbell's work was to include the entire country, it was understood that he was to give particular attention to the Rocky Mountain region, and that in connection with the regular geologic work he was to cooperate with the coal-testing plant at St. Louis by securing samples of coal to be tested.

In the Appalachian region geologic work was carried on at three localities—western Pennsylvania, eastern Kentucky, and central Alabama. In Pennsylvania about 750 square miles of coal territory was surveyed in great detail. In eastern Kentucky an area of about 950 square miles was thoroughly examined; and in Alabama a part of the coal field, about 500 square miles in extent near the city of Birmingham, was also examined with great care.

In the Rocky Mountain region a number of coal fields have been attracting the attention of coal operators and railroad men for some time. Reconnaissance surveys were made over several of these fields in order to provide the public with information in advance of active development in railroad construction. A large part of the Durango-Gallup field in southern Colorado and northwestern New Mexico, covering an area of about 2,000 square miles, was studied, and the various coal groups were mapped. Similar work, though perhaps in greater detail, was done over the larger part of the Yampa coal field of Routt County, northwestern Colorado. Great activity has been manifested in this field lately through the prospective building of the Denver, Northwestern and Pacific Railway through this field. The coals generally are of the bituminous variety, but in the northern part of the field there is a small area in which the coal has been converted to anthracite. This is due to local metamorphism, and the field is consequently of limited extent.

In Utah an attempt was made to examine the entire coal-bearing areas of the State in cooperation with the General Land Office. The shortness of the season permitted an examination only of the Book Cliffs area from the Sunnyside mine westward and also of the small coal field in the vicinity of Coalville. The Book Cliffs field is of great importance, and the maps and report prepared during this survey will doubtless be of great value. In addition to the regular systematic work on the Book Cliffs field some information was also obtained regarding coals in San Pete County. These are small outlying areas, and probably never will be of great value except for local use.

In Wyoming special attention was given to the coal fields of the southwestern part of the State in what is generally known as the Hams Fork coal field. This was examined with great care, with the object of determining both the fuel value and geographic distribution of the coals, as well as the amount of unclaimed coal land still remaining in the field. Incidentally considerable data were obtained regarding the coal field of the Bighorn basin, but this was done in connection with the investigation of underground water, and consequently was not of so detailed a character as the work just mentioned.

In North Dakota and Montana the work already begun by the North Dakota Geological Survey was extended so as to cover the valley of Little Missouri River south of the Northern Pacific Railway and the territory west into Montana. In the latter State reconnaissance work was carried on from the mouth of Yellowstone River as far up as Miles City. Heretofore the brown lignites of this region have not been regarded as particularly valuable for fuel purposes, but the tests made at the Government coal-testing plant on brown lignites as a fuel for the manufacture of producer gas show such excellent results that it seems possible that these low-grade fuels may become extremely valuable in the near future for the production of power. The geologic work was done in anticipation of a greater demand for this class of fuel.

Oil and gas.—Comparatively little work was done during the year 1905 on the oil fields of the country. In the Appalachian region Mr. Griswold continued his close structural studies, making very accurate and detailed maps of the oil-bearing sands of a part of western Pennsylvania. In California Mr. Arnold has taken up the work of Mr. Eldridge and during the latter part of the year has been engaged in an attempt to determine the conditions which control the accumulation of the heavy oil of California, so as to be able, if possible, to assist the driller in possible extensions of the old fields and in the discovery of new fields where oil is at present unknown.

Asphalts.—A report by Mr. Taff on the important ozokerite deposits of Utah is included in the present bulletin, the report being based on work done in 1905.

STRUCTURAL MATERIALS.

Cement.—In the summer of 1905 Mr. R. S. Bassler spent several months in western and southwestern Virginia examining and sampling the various limestone and shale deposits of that portion of the State. The important beds of shaly limestone ("cement rock") which form the basis of the Portland cement industry of the Lehigh district (Pennsylvania-New Jersey) were found to occur at many localities in the Shenandoah Valley, and these areas were carefully mapped and sampled. The results of this work will appear later as a report on the "Cement Resources of the Valley of Virginia."

Later in the season Mr. Eckel examined the cement prospects in the vicinity of Cumberland Gap (Tennessee-Virginia-Kentucky), where heavy beds of nonmagnesian limestone and shale outcrop in close proximity to the important Middlesborough coal field and where transportation facilities are satisfactory. His conclusions are stated in a brief report, in the present bulletin, on the "Cement Resources of the Cumberland Gap District."

Lime.—The most important lime-producing district of the eastern United States is that located in Knox County, Me., including the two well-known lime-burning localities, Rockland and Rockport. During the past season Mr. E. S. Bastin made a careful geologic survey of this district, and a report on his results is contained in the present bulletin. In this report Mr. Bastin shows the close relation of the geologic structure of the region to its economic importance. Obviously, in any search for good limestone beds, intelligent exploration must be based on a thorough knowledge of the geology of the limestones. In a folio now in preparation these facts will be taken up in more detail. Mr. Bastin's report is the first paper—since 1840 or thereabouts—which presents data of value on either the geologic or the technologic features of the Rockland lime industry.

Magnesite.—In the fall of 1905, on his return from Alaska, Mr. Frank Hess was enabled to spend a short time in the examination of the magnesite deposits of California. His report, which is published elsewhere in this bulletin, is a notably clean-cut piece of work, which marks a distinct advance in our knowledge of not only the geology but the technology of magnesite. The California magnesite deposits are, so far as now known, the only workable bodies of this mineral in the United States. High freight rates prevent their product from reaching the eastern market, so that the magnesia-brick plants of Pennsylvania and Ohio employ imported (Grecian and Austrian) magnesite exclusively.

The technology of magnesite is so imperfectly understood, even by the manufacturers who use the material, that investigations are now being carried on in the Survey laboratory to determine such important points as burning temperatures, relation of temperature to loss of carbon dioxide, relation of physical character to burning phenomena, etc. The results of this work will doubtless be of value to those interested in the American magnesite industry. Such investigations can rarely be carried on by any individual manufacturer, for few commercial laboratories possess the facilities necessary for accurate work at high temperatures.

Gypsum.—In the course of Survey work in the Western States a certain amount of data on their gypsum deposits have been collected. The present bulletin contains a brief report by Mr. C. E. Siebenthal on the gypsum of the Laramie district of Wyoming.

Stone.—Two important pieces of work on the building stones of the United States were taken up in 1905 by the Survey. The first was the preparation, by Prof. T. Nelson Dale, of a report on the "Slate Deposits of the United States." This is now in press and will be published in 1906 as Survey Bulletin No. 275.

Professor Dale also commenced work on the granite deposits of eastern United States. During 1905 he made a very careful examination of all the Maine granite districts, and his report on that State will be submitted before the close of 1906.

An event of great interest to the stone industry is described briefly in Professor Dale's paper on "A New Deposit of Slate in Maine," published in this bulletin. In the course of his geologic work in Maine, Professor Dale examined a bed of roofing slate west of the Monson area and well located with regard to new transportation routes. Laboratory tests and careful microscopic work prove that the slate is of fine quality, and it is probable that a new slate district of considerable importance will result from this discovery.

MISCELLANEOUS NONMETALS.

Glass sand.—The glass-making materials of several areas were studied by Survey geologists during the past year, and the present bulletin contains three reports summarizing the principal points brought out by their investigations. Mr. Burchard's paper on the glass sands of the middle Mississippi basin covers an area of particular importance to the glass industry. In the course of this work Mr. Burchard carried out chemical and physical tests, not only of glass sands now in use, but of sands which seemed to be worthy of attention for this purpose. The subject is one of interest, and work on it will be continued during 1906.

Graphite.—A report on the graphite deposits of Maine, by Mr. G. O. Smith, appears in this bulletin. In addition to its geologic and industrial value, this report is notable as containing reference to a new method for obtaining information as to the concentrating possibilities of any given graphite in advance of an actual mill test. Mr. Smith applied microscopic methods, and has determined the sizes to which the products must be reduced before satisfactory separation of the graphite will be possible.

Pyrite.—In connection with his work on the copper deposits of the Appalachian district Mr. Walter Harvey Weed examined a number of pyrite deposits which are likely to prove of value for their sulphur content rather than as copper ores. A report on these deposits will be published later.

Phosphates.—During the last two years interesting developments have occurred in the phosphate industry, discoveries of value having been made in Idaho and Utah. It was impracticable to place Survey geologists in these new districts in 1905, but it is hoped that examinations can be made during 1906.

GOLD AND SILVER.

In addition to the papers here included, which represent the results of recent work by the Survey in important precious-metal mining districts, other reports bearing incidentally on the subject of gold and silver will be found under the head of "Copper," on pages 93 to 145, and "Lead and zinc," on pages 166 to 170.

ORE DEPOSITS OF BEAR CREEK, NEAR SILVERTON, COLO.

By W. H. Emmons.

General description.—The Bear Creek mining camp is in the northeast corner of the Needle Mountains quadrangle, near the head of Bear Creek, a tributary of the Rio Grande near its source. It includes also a group of claims at the extreme head of Elk Creek, to the west just over the continental divide. It is about 17 miles from Silverton; 9 miles of this distance is over a wagon road by way of Howardsville, up Cunningham Gulch, and the remainder is over a good pack trail. The district may also be reached by wagon road from Creede, a distance of about 40 miles, and in the summer of 1905 a trail was being constructed from Elk Park, on the Denver and Rio Grande Railroad, only about 9 miles away. The country is extremely rugged and much of it is above timber line. The region was prospected as early as 1878. The Gold Bug mine was among the first located and was sold to Kansas City parties, who, it is said, took out about $50,000 worth of very rich ore. The Good Hope and Sylvanite have also produced considerable amounts, and shipments have been made from a number of other properties. The entire district has produced about $200,000, chiefly in high-grade tellurium ores. Nearly all of this was packed out by mule trains.

When the camp was visited in August, 1905, the most largely developed mines had been idle for years and the portals of several of their tunnels were blocked with snow and ice, so that entrance to all the workings was impossible. A number of smaller properties were being developed, and the data gained from the examination of these and from the surface workings of the larger mines appear to be in full accord with those reported for the workings then inaccessible.

Geology.—The geology of the Needle Mountains quadrangle is treated in folio 131 of the United States Geological Survey, by Whitman Cross and Ernest Howe, and their geological map was used as a basis for this report.

The Bear Creek deposits are located in an area of pre-Cambrian schists, slates, and quartzites, partly covered by San Juan andesite tuffs and by later flows. The Archean schists, which are the oldest rocks, have a laminated, streaked appearance and are composed mainly of mica, quartz, and feldspar. Seams or veins of quartz, often as much as 3 or 4 inches wide, are common. These are known to prospectors as "bull quartz" or "barren quartz," and are carefully avoided.

The slates and the quartzites belong to the Uncompahgre formation and, though pre-Cambrian, are younger than the Archean schists, upon which they rest unconformably. They are the metamorphosed products of shale and sandstone. Certain portions of the shale were sandy and after metamorphism resulted in a hard, dense, and easily fractured rock, much like the quartzite.

The pre-Cambrian rocks are rather closely folded, the axes of the folds trending generally a few degrees south of east. They are also faulted, the faults running nearly east and west, approximately with the strike of the beds. The andesite tuffs and flows rest upon a very irregular eroded surface of the pre-Cambrian rock. They have suffered little change since their deposition.

A long, narrow fault block of the Uncompahgre quartzite enters the area just south of Beartown and extends nearly due west to the head of Elk Creek. On the north it is in faulted contact with the Archean schist and on the south with other Uncompahgre schist and quartzite. It is partially covered by the Tertiary volcanics. Where it is the surface rock it stands up conspicuously above the surrounding country and is very generally mistaken for a dike, which form is strongly suggested by its long, narrow, regular outline. A number of claims are located along this fault block, among which are the Good Hope, the New York and Brooklyn, and the Silverton. The lodes cross this fault block nearly at right angles to the faults. They are more conspicuous in the quartzite than in the surrounding slate and schists.

Ore minerals.—The ore deposits are narrow fissure veins composed chiefly of white quartz, in which are scattered small masses or pockets of gray ore minerals. While quartz is by far the most important gangue mineral, calcite, barite, and a soft white material, probably kaolinite, are also present. The metallic minerals are a telluride of gold and silver (probably petzite), tetrahedrite (or gray copper), iron pyrite, marcasite (or white iron pyrite), copper pyrites, bornite (or peacock ore), galena, sphalerite, arsenopyrite, limonite, hematite, malachite, and azurite. None of these minerals have been discovered in sufficient quantities to be of economic importance except the telluride and the gray copper. These occur very intimately associated. What appears to be a single mineral from the Good Hope mine gave tests for tellurium, copper, arsenic, antimony, and sulphur. This mineral has the physical properties of gray copper. The tellurium mineral probably occurs also in a much purer state, since roasted specimens which have been taken from the Good Hope mine show light-yellow globules of considerable size sticking to the white-quartz gangue.

White iron pyrite is found in relative abundance, especially at the Sylvanite and Kankakee properties. Its occurrence is similar to that of the ore minerals and it has been mistaken for a telluride. It may be distinguished from the tellurium ores by the darker color of its powder, its greater hardness, and its tendency to assume botryoidal or roundish form.[a]

Pyrite and chalcopyrite (copper pyrites) occur as small masses and crystals in the gangue and to a certain extent in the country rock. Assays of these minerals show that they carry very low values in gold and silver. The copper, lead, and zinc minerals have not been found in sufficient quantities for profitable exploitation.

Ore deposits.—Some of the veins are well defined and their decomposed outcrops marked by yellow iron stains may be followed along the surface almost continuously for several hundred feet. Their usual trend is nearly north and south. Those of an important group run about S. 7° W. The veins are usually vertical or are inclined less than 10° from that position. The fissures do not appear to be closely related to the larger structural features of the country, but cut the faults, the axes of the folds, and the fissility of the rocks at a high angle. The fissures cut all the rocks, but are most clearly defined in the quartzite or in the siliceous portion of the slate. These rocks are strong and brittle, and are better adapted to forming and holding open the cavities in which the quartz and ore may be deposited than are the slates. Along the outcrops of the Gold Bug lead there are a number of shallow surface workings. Some of them are said to have produced several hundred

[a] Test for tellurium: Take a piece of the mineral about the size of a 0.22 ball, crush to fine powder, place in a glass vessel and pour in about as much concentrated sulphuric acid as would fill an ordinary thimble. Heat gently. If tellurium is present, the solution will assume a reddish-violet color.

dollars' worth of ore. They are all in hard, rather siliceous phases of the slate, and it is reported that in the development of the Gold Bug mine the profitable ore pockets were found in siliceous walls.

The veins vary in width from the thickness of a knife blade to 2 or 3 feet, and the Gold Bug vein is said to reach a maximum of 6 feet. While they usually have pretty well-defined limits, there is often a considerable amount of the country rock contained in the vein matter, so that in certain cases where the country rock is cut by quartz stringers it is impossible to determine the wall definitely. For considerable distances the veins may be entirely barren of the precious metals, while at the end of this barren streak a rich pocket sometimes occurs in which are large quantities of high-grade ore. When this pocket has been removed another barren streak is apt to be encountered. This erratic distribution of the ore has had a tendency to discourage continued effort at exploitation, and while a considerable amount of development work has been done the principal mines are at present idle.

Summary.—At Bear Creek, Needle Mountains, Colorado, gold and silver telluride, gray copper, and other minerals occur as pockets and stringers in quartz veins which cut the Uncompahgre quartzites and shales and older pre-Cambrian formations. These veins appear to have no intimate relation to the folding, faulting, or schistosity of the rocks. They are most clearly defined in the quartzite or in the more silicified portions of the shale.

THE HAHNS PEAK GOLD FIELD, COLORADO.

By Hoyt S. Gale.

LOCATION.

Hahns Peak is situated in northwestern Colorado, about 15 miles west of the Park Range, which is here the continental divide. As it stands apart from the main range, its sharp, white cone is a conspicuous landmark from a large part of Routt County. It was occupied as a triangulation station by the United States Geological Survey in 1901, and its elevation was then determined as 10,862 feet, which is 44 feet less than the barometrical measurement by the Fortieth Parallel Survey in 1872. At the very foot of the mountain is situated the little town of Hahns Peak, the county seat of Routt County. Several towns of this county along Yampa River have now far outgrown it in size and commercial importance. It is reached from Rawlins, Wyo., on the Union Pacific Railroad, to the north, distant about 110 miles by stage road; and from Wolcott, Colo., on the Denver and Rio Grande Railroad, to the south, also about 110 miles by stage road. Travel is mainly by way of Wolcott.

The peak and the broad stretches of park land that lie about its base have long been known as a gold camp. Its placers are reported to have been discovered in 1865. Eight or ten years ago, with the working out of the richer gravels, prospecting was begun higher up on the mountain slopes in search of the original veins. This search, however, has not met with much success.

FIELD WORK.

During the first week of October, 1905, an opportunity was afforded to the writer to make a hasty examination of this district, the results of which are chiefly expressed in the topographic and geologic maps that accompany this report. Had time permitted, the work might properly have been extended to include Little Red Park, Big Red Park, and the neighboring ridges within a few miles' radius north of the peak, and also a larger area in and about the park land to the south. Prospecting has shown the gravels of these parks to be gold bearing. The geologic structure of the region is more complicated than is expressed on the map (Pl. I), but enough is shown to indicate the general problems involved.[a]

This region was visited in 1872 by S. F. Emmons, then of the Fortieth Parallel Survey, and a general description of the area and its rocks is given in the King report.[b] Since this first report mention has been made of this district in a few publications.[c]

GEOLOGY.

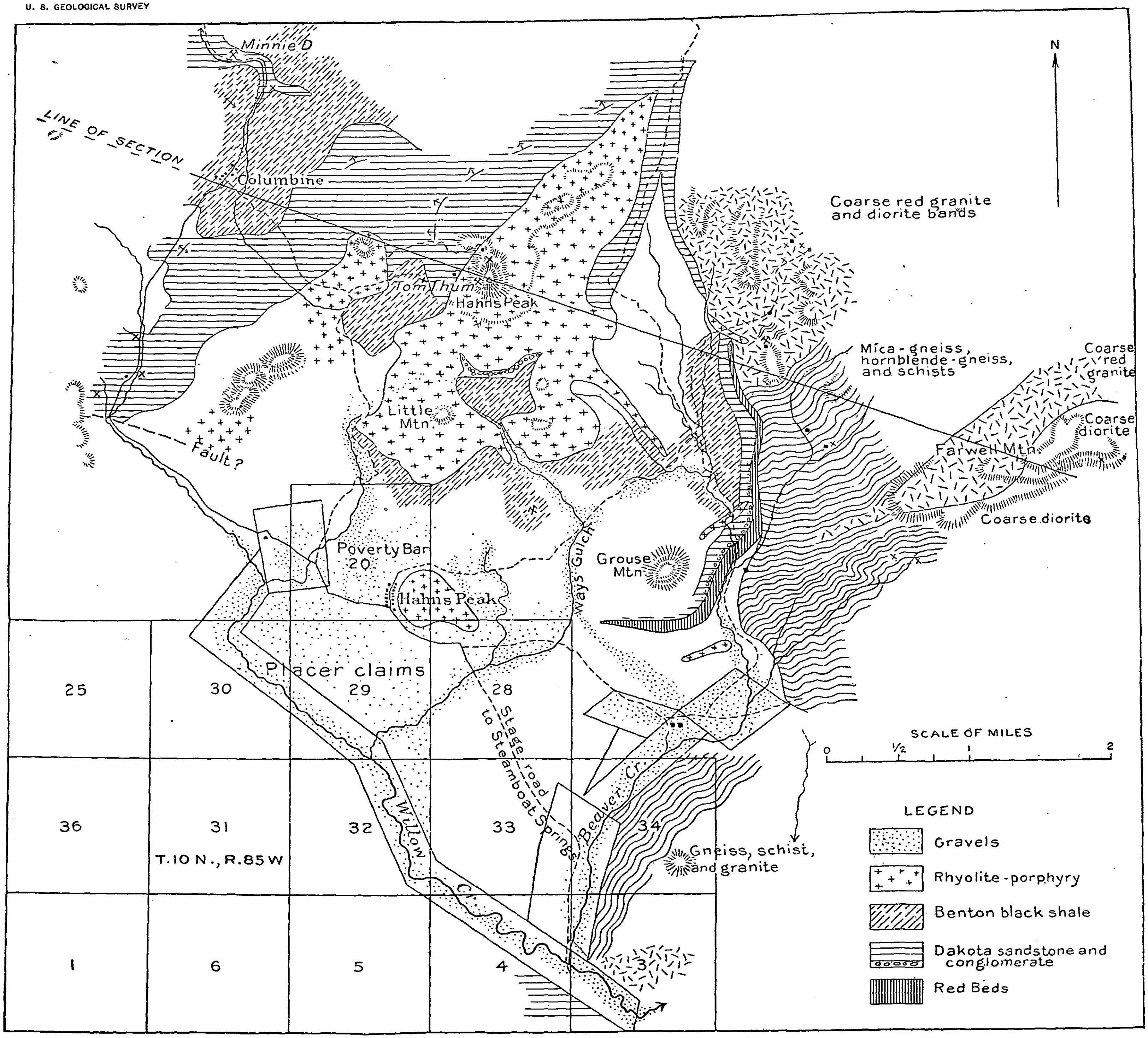
ROCK FORMATIONS.

General description.—The main mass of the Park Range, which is part of the Rocky Mountains, is a vast complex of granitic rocks, gneisses, and schists, which have been hitherto referred to the Archean. West of the Park Range lies the Colorado Plateau, made

[a] The writer wishes to make acknowledgment to Messrs. Charles Blackburn and Thomas A. Brown for the courtesies and assistance which they extended to him in the field.

[b] King, Clarence, Geological Exploration of the Fortieth Parallel, vol. 2, 1877, pp. 173 et seq.

[c] Parsons, H. F., and Liddell, Chas. A., The coal and mineral resources of Routt County: Colorado School of Mines, Bull. 1, vol. 1, 1903. Draper, Marshall, Hahns Peak: The Colliery Engineer, May, 1897.



GEOLOGIC MAP OF HAHNS PEAK AND VICINITY, COLORADO, SHOWING DISTRIBUTION OF ROCK FORMATIONS AND PLACER GROUND.

up largely of sediments of Mesozoic and later periods. These sedimentary rocks are sharply tilted, folded, and broken along the immediate flanks of the older mountain mass and extend away to the west in gentler folds until they dip beneath the mantle of less consolidated Tertiary sediments.

Hahns Peak and the Elkhead Mountains are uplifts of recent intrusives which break through the sedimentary rocks of the eastern portion of the Colorado Plateau. The region of these later uplifts is one of marked diversity of features. The rugged peaks and ridges of igneous formation are interspersed with patches of the plateau topography and structure (see Pl. II).

The rock formations about Hahns Peak are similar to those found along the eastern base of the Rocky Mountains.

ARCHEAN.

The oldest are the Archean gneisses, schists, and granitic rocks already referred to. The rocks of Farwell Mountain belong to this general series. They consist of gneisses, schists, diorites, coarse red granite, pegmatites, and other rocks. They are largely, if not wholly, igneous, although some of the schists may represent ancient and much altered sediments. Their general distribution only is indicated on the map.

RECENT IGNEOUS ROCKS.

More recent igneous rocks of at least two distinct types, rhyolitic and basaltic, are present. One of these, locally known as the "white porphyry," forms the core of Hahns Peak. This rock is light colored, usually more or less coarsely porphyritic, showing much quartz in distinct rounded masses, and often phenocrysts of orthoclase feldspar. In the outlying dikes these feldspar crystals are often large and very perfectly formed. The groundmass varies in color from white to pink and gray. Thin sections have been prepared from specimens of this rock collected from the summit of the peak, from the wall rock of the Southern Cross tunnel, and from the smaller knobs south of the main peak. These slides were examined by Mr. Albert Johannsen, who gives the following petrographic description. Under the microscope the slides show phenocrysts somewhat less in amount than the groundmass. The phenocrysts consist of quartz and orthoclase about equal in amount, plagioclase in less amount than either of the foregoing, and a still smaller quantity of biotite mica. The groundmass is apparently a devitrified glass of feldspar-quartz aggregate with numerous biotite shreds. Both phenocrysts and groundmass are considerably altered. The rock is classified as a rhyolite-porphyry containing considerable plagioclase.

The mass composing Hahns Peak seems to have been thrust up from below, in places lifting and arching the Cretaceous rocks and in other places cutting through the formations (see fig. 1). The main summit has the topographic outline of a volcanic peak, but this summit is only a small part of a huge mass of rhyolitic material of fairly uniform composition. The irregular surface of this intrusive mass is exposed on several minor peaks on various sides of Hahns Peak, and many dikes of the same material radiate into the surrounding sediments. These dikes cut through instead of arching the sediments.

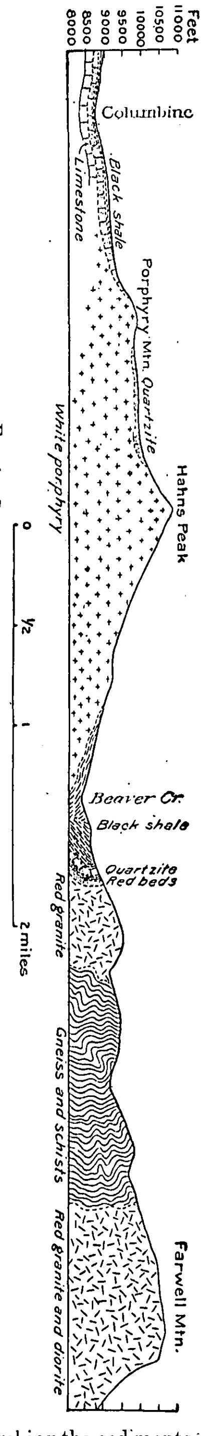


FIG. 1.—Cross section through Hahns Peak and Farwell Mountain.

The structure that this peak suggests is that of a laccolite—a lenticular body of igneous rock intruded into the bedding planes of a sedimentary series. Its formation is explained as the result of an ascending stream of molten rock, which expands laterally before reaching the surface and, by lifting the overlying beds, accumulates in a great mass in the chamber so made. Subsequent erosion of the overlying sediments may expose various portions of its irregular surface. That the Hahns Peak mass is of a lenticular character is no more than supposition as a probable explanation of its relations to the surrounding sediments, for no direct evidence as to the character of the base of this mass was observed.

The second intrusive is a typical olivine basalt.[a] It is shown in a prominent dike north of Hahns Peak between Columbine and Little Red Park. This rock forms a large part of the Elkhead Mountains to the west and southwest of Hahns Peak. Both of these intrusives cut through Cretaceous rocks and are therefore of later age. By analogy with similar occurrences elsewhere they are probably of Tertiary age.

SEDIMENTARY ROCKS.

Red Beds.—The oldest of the sedimentary series here shown are the "Red Beds" of probable Triassic age. They are composed of red sandstone, red shale, and conglomerates with well-rounded pebbles of granitic material, such as make up this formation in many parts of the West. The one undoubted exposure of these beds in this field is in normal position, lying next the Archean rocks at the western foot of Farwell Mountain. On the road between Hahns Peak post-office and Columbine are some exposures of variegated shaly soil and some prospect pits in material that strongly suggests the Jurassic formation, but these are not represented on the map.

Loosely cemented, very coarse conglomerates of rounded pebbles of granitic rocks are also shown in several places. These have likewise been omitted from the map on account of uncertainty as to their extent and proper classification. They were found high on the mountain slopes and in the ravines in the vicinity of the white porphyry. Whether they belong with the "Red Beds" at the base of the sedimentary series or are scattered patches of overlying and considerably later Tertiary beds could not be determined. If they do belong to the "Red Beds" series, it seems strange that they should have been so little altered by their proximity to the intrusive rock of Hahns Peak, for the Dakota quartzite above the "Red Beds" has been very completely vitrified.

Dakota formation.—The next formation showing in outcrop is the Dakota quartzite and conglomerate. It is composed of beds of conglomerate, characterized by perfectly rounded pebbles of exceedingly hard material, of white and gray quartz and a darker flint. Its upper portion is white, even-grained sandstone and quartzite. Its unusually complete silicification in most parts of this field is attributed to the effect of the intrusion of the Hahns Peak porphyry. It lies nearly flat over a considerable area about Columbine, rising on the north and west flanks of the peak to within a few hundred feet of the summit. In scattered patches it also shows at many other places throughout the field. The shaft known as the "Minnie D," just north of Columbine, was put down through this formation where it is nearly horizontal and should give a good measure of its thickness. This shaft passed through the Dakota into a compact blue limestone below, which is probably the Jurassic limestone, found elsewhere immediately below the Cretaceous. A record of the measurements in this shaft is given later under a description of this property.

Benton shale.—Many of the shafts about Columbine pass through a considerable thickness of black shale before striking the Dakota quartzite. This shale is similar in character and position to that called Benton east of the mountains. Where not baked by igneous contact, it is soft and very dark, with calcareous seams. Shells of oysters and *Inoceramus* were found in these calcareous seams. The upper valley of Beaver Creek seems to have been opened out on a narrow syncline of these shales, lying between Farwell Mountain and

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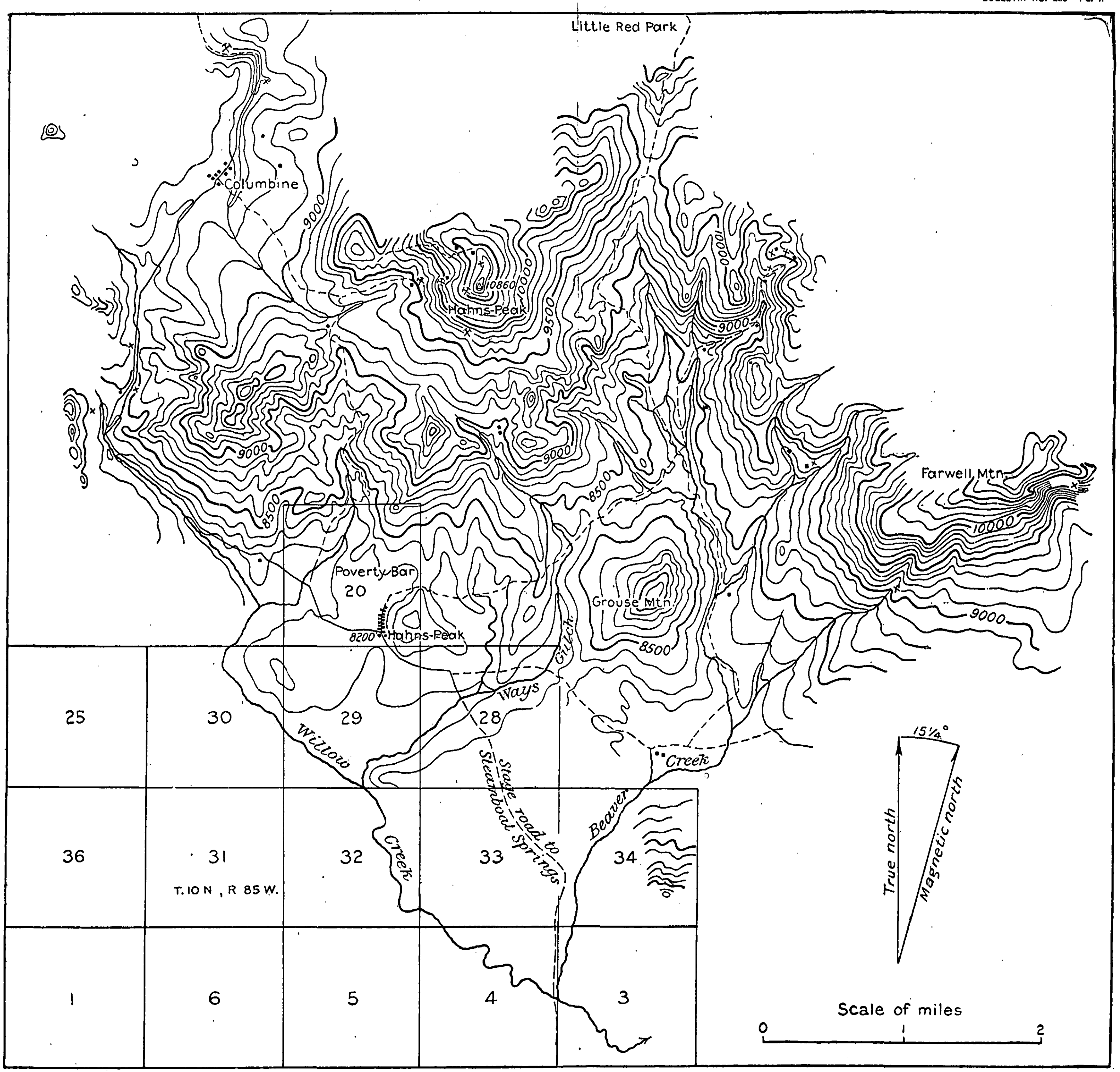
[a] Thin sections of this rock were also examined by Mr. Albert Johannsen.



HAHNS PEAK AND VICINITY, COLORADO.

the uplift of the Hahns Peak porphyry. Similar shales show at many other parts of the field, and wherever exposed over a considerable area they take the form of an open flat or park. It is probable that the large parks now buried in rock débris have been eroded on areas of these soft black shales. Above the black shales, but not showing within the field of this report, are light-colored sandstones and shales, 2,000 to 3,000 feet thick, carrying many coal seams.

Recent gravels.—These deposits are in two forms, the "bars" and the stream gravels. The bars are original alluvial fans, partly cut away by recent erosion. The remaining portions of these fans stand above the present stream grades to a height of perhaps 50 feet. Their position at the mouths of narrow gulches along the margins of the parks is evidence that they were built up of the rock débris washed from the mountain slopes. The stream beds in the open parks are bowlder and gravel filled, in some cases to a considerable depth below water level. Practically all of the park land in this vicinity is buried in bowlder and gravel deposits, all of which seem to be more or less gold bearing.

DEVELOPMENT.

THE PLACERS.

On the south side of Hahns Peak the bars have been worked in two places. A considerable pit has been left by the washing on the bar immediately west of Ways Gulch, but no report was obtained of the results of this work. The most extensive workings in the field have been those of Poverty Bar. On a lower portion of these deposits the town of Hahns Peak itself is located. Here the gravels stand some 40 to 60 feet above the present stream grade. A large proportion, variously estimated at from 75 to 90 per cent, of this material is composed of rounded bowlders and pebbles of the white porphyry, vesicular in appearance, the cavities being probably those left by weathering out of the feldspar phenocrysts. Besides the white porphyry are pebbles of vein quartz, quartzite, conglomerate, black shale, and slate, and some pebbles of granite, both angular and rounded, the whole very slightly agglomerated. The gravels are covered by a thin layer of soil. All of this rests upon a bed rock of stiff sandy clay, very uniform in character and similar to the bed rock found throughout the field.

Water for hydraulicking has been brought in a long ditch (about 27 miles) from a headwater tributary of Elk River to the east of Farwell Mountain. A large proportion of this bar has been worked over, but it is claimed that there is as much good ground left as has been washed. It is said that $84,000 was taken from it in one summer.

The earliest and richest of the workings were in the stream-level gravels of Ways Gulch at the western foot of Grouse Mountain. These were worked over with shovel and sluice box, and are reported to have yielded large returns. The stream bed was narrow, however, and the gravels there have long since been worked out. A test pan taken from these tailings showed several coarse colors.

The lower courses of these streams have been thoroughly prospected and the gravels have very uniformly shown values. That these values were not sufficient to repay working by hand is evident from the fact that these claims have never been worked. After leaving the bars the streams come down to such light grades that much difficulty would be encountered in the disposal of the tailings. Where these streams leave the park (about at the southern edge of the area shown in the topographic map), they again fall off more rapidly, and would here afford a dump. Some of the placer claims now held on this lower ground are represented on the geologic map, to indicate roughly the extent of these low gravels.

The question of the origin of the Hahns Peak gold is by no means solved. In character it is in large part moderately coarse flake gold, and is alloyed with silver to such an extent that it sells for about $13 an ounce. Many very small nuggets are found inclosed in vein quartz. Away from the mountain slopes, in the open bottoms, the gold is said to be slightly purer. It is possible that the gold of the placers is a reconcentration from the loosely consolidated conglomerate already described under "Red Beds." The Archean material, of which this conglomerate seems to be wholly composed, is commonly the original seat of gold-quartz veins. The wearing down of such granitic material is a common means by which such veins are worked over and concentrated in nature. The conglomerate beds may be the base of the Hahns Peak laccolite. Gold once transported with these pebbles from an older mountain mass may have been later resorted and concentrated on the slopes of Hahns Peak.

Reports of assays of the Hahns Peak Porphyry claim a very uniform content in gold, of from 30 to 50 cents per ton throughout this rock. This indicates the possibility that the porphyry may be the source of the metal in the placers. A number of tunnels have been driven into the peak itself in search of the original gold veins. Most of this work has now been abandoned. As the gold in the porphyry is in such a finely divided state and as no nuggets or gold-quartz seams have ever been discovered there, the weight of this negative evidence lies against the theory that the gold was derived from the porphyry. On the other hand, the most productive of the placer grounds lie in such position that their material has been derived from the slopes of the porphyry peaks. Seventy-five to ninety per cent of the pebbles in the gravels are of the white porphyry itself. It is probable, therefore, that the gold has been in considerable part derived from the Hahns Peak porphyry. Although the occurrence of the coarser gold has not been discovered within the mass of the porphyry itself, it may have been deposited at the time of eruptive activity in and about what was then the contact of these igneous and sedimentary rocks. Later erosion and the present mantle of slide rock may have obscured this zone.

VEIN DEPOSITS.

In this field two lode properties have shipped ore to the smelter—namely, the Tom Thumb and the Minnie D. Both have been idle for a number of years. The Tom Thumb was not visited, and inspection of the Minnie D. was limited to an examination of the dump. The Tom Thumb is situated on the west side of Hahns Peak, near the summit. The ore as shipped from the Tom Thumb is a galena, much of which is altered to a sand carbonate. As reported, it occurs along a zone of brecciation within the Hahns Peak porphyry. Seen from below, the mine has the aspect of a tunnel driven in on the shearing zone of a huge landslip. This has the corroborative evidence that the tunnel is reported to run in nearly parallel to the mountain face. Assays from a representative shipment of about 18,000 pounds gave 52 ounces of silver, 2 ounces of gold, and 51.8 per cent of lead per ton. The mine is reported to have shipped 200 tons of ore, in part to Denver by wagon and in part to Leadville The Minnie D. is situated near Columbine, in an elevated flat of approximately horizontal rocks. It was opened by a vertical shaft 325 feet deep. The record of strata passed through, as furnished by Mr. Daniel Stukey, of Steamboat Springs, Colo., is as follows:

Section at Minnie D. mine, near Columbine, Colo.

	Feet.
Black shale	25
Quartzite	42
Shale	80
Quartzite and conglomerate	35
Limestone and dolomite	140+

All these rocks were found in the dump. It is probable that they represent the Benton and Dakota of the Cretaceous and the Jurassic limestone. The ore was not seen, but $1,500 worth is reported to have been shipped to Leadville, smelter returns giving 0.42 ounce gold and 8.32 ounces silver per ton. At the time of visit the works had been abandoned for several years.

The Southern Cross tunnel lies on the south side of the peak, about 1,000 feet below the summit.

This passes through the following strata:

Section at Southern Cross tunnel, Hahns Peak, Colorado.

	Feet.
Porphyry talus slope	75
Solid white porphyry	50
Light-colored plastic kaolin clay	125
An apparent fault breccia, ending in a black clay shale	28
Solid white porphyry	322
	600

Mr. Richard Paulson is still at work on this tunnel. This development is important as showing that zones of solfataric action exist within the mass of white porphyry. Some mineralization has taken place along the breccia zone, and a few little streaks of galena and silver have been found. The plastic kaolin clay is interpreted as the product of decomposition in place of the white porphyry, and the breccia of angular fragmen s as marking a zone of faulting. The porphyry beyond the breccia to the breast of the tunnel is considerably altered, as evidenced by the kaolinization of the feldspars.

The Oro-Cache tunnel is on the east side of the peak. It is said to have been driven 600 feet into the white porphyry in search of the gold veins. It is now abandoned and inaccessible.

The Ely-Young tunnel, on the west side of the peak, passed through a porphyry talus slope for about 150 feet, then through the black shale of the Benton to the Dakota quartzite, about 400 feet in all, in the expectation of finding ore between these rocks. At the time of visit the tunnel had passed into the quartzite, but no mineral had been found.

On Farwell Mountain is a group of prospects entirely distinct from those that have been described from the rest of this field. About thirty claims are located here, on most of which assessment work only has been done. A few of the developments have been carried in from 100 to 200 feet. The ore indications seen were of copper, mostly impregnations of a coarse granite and pegmatite, and of horneblende-gneiss and diorite, usually near the contact of these two groups of rocks. There are also quartz veins carrying mineral, but such as were seen were in the form of stringers, with no evidence as yet of strong fracture zones. The minerals were mainly the alteration products malachite and azurite, with some chalcopyrite, and possibly bornite and chalcocite. These are said to have assayed values in gold and silver. No workable ore bodies have yet been discovered.[a]

CONCLUSION.

Interest in this field is revived with the expected advent of the Denver, Northwestern and Pacific Railroad. Nearer railroad facilities may render feasible projects which are not so under present conditions. In the placer grounds the deposits that would pay under the methods of washing hitherto employed are mostly worked out, but they may yet be worked to a profit by hydraulicking or by dredging. The difficulty in hydraulicking in a great part of the field is the lack of grade for the disposal of tailings. Dredging has not yet been tried, though the position of the gravels, the softness of the bed rock, and an ample water supply are all favorable to this method of treatment.

With regard to the lode prospects the work already done shows that there has been mineralization within the mass of the porphyry of Hahns Peak, but as yet the character of the deposits, whether simple impregnation of the country rock or actual lode deposits, has not been satisfactorily determined. Ore is also said to have been found in the Minnie D., following bedding planes in the sedimentary beds surrounding the porphyry body, but such indications do not offer much hope for permanent deposits unless they should be found in the underlying limestone. This limestone, however, was not found at the surface.

[a] For a more complete description of the deposits and associated country rocks of similar character, see Spencer, A. C., The copper deposits of the Encampment district, Wyoming: Prof. Paper U. S. Geol Survey No. 25, 1904.

As a general rule it may be said that it seems inadvisable to drive long tunnels or sink shafts in barren rock, as has been done in some cases, in the remote hope of striking an ore body. Only actual indications of ore should be followed by such explorations until the existence of workable bodies has been proved by workings sufficiently extensive to permit the determination of the geologic character of the deposits that may exist here.

For the deposits in the Archean, where the probable values lie in the copper ore, it must be borne in mind that these ores make a disproportionately large showing at the surface. Until the existence of strong vein deposits has been actually proved by sinking on the outcrop, it is inadvisable to drive crosscut tunnels to cut a lode in depth which shows, as do most of the prospects, only little stringers and impregnations of the country rock at the surface.

THE IDAHO SPRINGS MINING DISTRICT, COLORADO.

By J. E. Spurr and George H. Garrey.

INTRODUCTION.

A preliminary report on the geology and ore deposits of the Georgetown quadrangle, based upon work done in the vicinity of the towns of Georgetown, Silver Plume, and Empire, appeared in 1905.[a] Last summer (1905) Mr. Spurr spent ten days and Mr. Garrey was engaged for six weeks in studying mines south and west of Idaho Springs—that is, in the northeastern, previously unstudied portion of the Georgetown quadrangle. The following brief report presents the main results of this second season's work.

Idaho Springs, which is on a branch of the Colorado and Southern Railroad, lies about 40 miles due west of Denver, in the valley of Clear Creek, near the junction with Chicago Creek. It is the largest town in Clear Creek County and has a population of about 2,500.[b] There are at least 12 concentrating mills operating at Idaho Springs, which is the milling center for the district.

TOPOGRAPHY.

Idaho Springs has an elevation of about 7,525 feet[c] above sea level. From this altitude in Clear Creek Valley the mountains rise by gentle slopes to elevations as great as 11,000 feet a few miles distant. In their rounded forms, however, the mountains here contrast strikingly with the rugged peaks near Silver Plume and Georgetown.

The topographic map of the Georgetown quadrangle on the scale of 1 mile to the inch, made by Frank Tweedy during the summer of 1903, is now in print.[d] This map and the Idaho Springs special map, on a scale of 1,000 feet to the inch, made by Pearson Chapman during the summer of 1904, were used as a basis for the geological work.

GEOLOGY.

General description.—The rocks near Idaho Springs are almost identical with those in the vicinity of Georgetown. The oldest formations of the Rocky Mountains, presumably pre-Cambrian, form a "complex" comprising the main mass of the mountains. These rocks include schists, gneisses, basic igneous rocks of the nature of hornblendites and diorites, granites, and pegmatites.

All these rocks are cut by later intrusive bodies of porphyry.[e] The dikes of porphyry, which vary considerably in color and texture, often contain angular fragments of the wall rocks and of fine-grained contact phases of the porphyry itself. They are much more numerous in this part of the quadrangle than in the vicinity of Georgetown and Silver Plume. That the porphyry as a rule is earlier than the veins is shown by the fact that

[a] Spurr, J. E., and Garrey, G. H., Preliminary report on the ore deposits in the Georgetown, Colo., mining district: Bull. U. S. Geol. Survey No. 260, 1905, pp. 99–120.
[b] Census report for 1900.
[c] Idaho Springs special topographic map, by Pearson Chapman.
[d] Copies of this map can be obtained from the Director, U. S. Geological Survey, Washington, D. C.
[e] For a fuller description of these rocks, see Bull. U. S. Geol. Survey No. 260, 1905, pp. 101–106.

the veins pass in some cases from granite or gneiss into and through a porphyry dike and continue uninterrupted into granite or gneiss on the other side.

Placer deposits.—The first discovery of pay gold in Clear Creek County, and one of the first in Colorado, was made by George Jackson about the 1st of April, 1859,[a] on Chicago Creek, just above its junction with Clear Creek.

This is considered by many to have been the first discovery of gold in Colorado, but, according to Hollister, B. F. Langley had, about the end of the preceding January, found placer deposits in a gulch on South Boulder Creek. These deposits, which were known as "Deadwood Diggings," had by the end of March produced considerable gold and were affording employment to quite a number of men. Small amounts of gold had also previously been encountered near Golden, and on Ralston Creek, a small tributary of Clear Creek.

On Clear Creek placer mining was prosecuted from Grass Valley Bar, 3 miles below the mouth of Chicago Creek, to the forks of the South Branch, some 9 miles above this same point.

By the end of May, 1859, there were nearly 300 men employed at "Jackson Diggings" and on the various claims for several miles up and down Clear Creek from this point. These deposits yielded good returns to some of the workers for a great many years; in fact, the yield of the precious metals in Colorado previous to 1864 was almost entirely derived from these placers and from the sluicing of the decomposed surface ores of the veins, for the silver mines were not operated until 1865, and the unaltered gold-bearing sulphides could not be treated with profit. The placers were most profitably worked between the years 1859 and 1863.

The placer gold deposits of Clear Creek County may be classed as (1) river-bar placers, (2) stream placers, and (3) bench placers. The river-bar deposits are those on gravel flats in or adjacent to the beds of the streams. The stream deposits consist of the deposits of bowlders, gravel, and sand filling the channels and forming the beds of the streams. The bench placers are ancient stream deposits which are at present represented by remnants of old stream terraces located at a considerable elevation above the level of the present water courses. There are three conspicuous lines of terraces. While not of glacial origin, the lowest of these, which is about 25 feet above the present stream beds, consists largely of glacial material which has been worked over and transported to its present position by streams subsequent to the period of glaciation. The second gravel terrace, which, according to Mr. S. H. Ball, is possibly pre-Glacial in origin, is found 55 feet above the creek bed. The third set of terraces is 180 feet above the channels of the present streams and consists often of indurated river gravels of late Tertiary or early Pleistocene age.

The principal deposits along Clear Creek occur in the vicinity of Idaho Springs and extend from the junction of Fall River and Clear Creek to the forks, several miles below the town, where North Clear Creek, which flows through Blackhawk, joins the main stream.

"Jackson Diggings," where the first discovery of gold in the county was made by George Jackson in April, 1859, is located on Chicago Creek near its junction with Clear Creek. The exact site where Jackson first found gold is said to be beneath a large willow tree on the road north of Chicago Creek, about halfway between the Jackson and Waltham concentrating mills; this site is now included in what is known as the "Edwards Placer." The material at "Jackson Diggings" consisted of coarse gravel and sand, occurring as bars or flats in or adjacent to the streams, and of deposits forming the stream bed itself. The low benches along the sides and in places on top of the low ridge or spur of land which separates Chicago Creek from Clear Creek just above their union were also worked extensively. Much of this material was sluiced at very large profits in the early days. The deposits of Spanish Bar, which was the name given to the portion of Clear Creek extending from the junction of Fall River and Clear Creek to a point below the Stanley mine, consisted mainly of a mass of bowlders of all sizes, gravel, and sand, filling the channel of the stream, which here runs in a comparatively narrow valley.

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[a] Hollister, The Mines of Colorado, 1867, p. 60.

On the south side of Clear Creek an old river terrace or bench extends from the eastern edge of the Georgetown quadrangle along the south bank of Clear Creek to the western edge of the town of Idaho Springs. This terrace is cut through by both Soda and Chicago creeks and is beveled by Clear Creek. The upper part of the scarp due to the action of the present stream is about 100 feet above the present valley, while the upper part of the terrace, which has a slope making a considerable angle with the present stream, is about 180 feet above Clear Creek.

The terrace gravels, which are now covered by the Arthur and Doherty placer claims, were formerly extensively worked with very profitable results. This terrace, which is located in the southeast angle formed by the union of Soda and Clear creeks, is a bed rock bench of porphyry which in rare instances reaches the surface, but is usually covered with a river deposit averaging 40 feet in thickness. The lower 20 feet of this deposit consists of large rounded bowlders, gravel, and sand, while the upper portion is composed of finer gravels and silts which are capped by talus deposits having an average thickness of 6 feet. The bedding of the materials in these deposits dips at a considerable angle toward Clear Creek.

Good values were found in these deposits, the best ones usually occurring either in the deeper gravel-filled channels or right on bed rock. Where the detritus coating above bed rock was very thick tunnels were run into the stream banks or else shafts were sunk and drift mining was resorted to to expose the gold, which occurred on bed rock in the natural riffles due to the roughness of the old stream bed. Many hundreds of feet of tunneling and drifting on bed rock were run during the period of active development, and according to Fossett[a] there was one tunnel over 900 feet long extending into the bank and hillside adjoining the creek. That the deposits are fairly well consolidated is shown by the fact that untimbered drifts and tunnels run some 40 or 50 years ago can still be explored to a considerable extent.

The high bench found at the junction of Soda and Clear creeks is not visible below this point on the south side of Clear Creek but appears again on the north side about one-fourth mile downstream. At the latter place is a horizontal or slightly sloping shelf or ledge of coarse conglomerate and soft sandstone or granitic arkose of a character somewhat similar to the placer deposits on the other side of the valley. This fairly well-indurated conglomerate, which is comprised chiefly of rounded masses of gneiss and granite but also contains some rounded pebbles of porphyry, is of limited extent and is plastered unconformably upon the rather steep gneiss walls of the valley at this point.

Placer mining remained an important industry in Clear Creek County and added materially to the gold production up to the early eighties. Since that time, however, although considerable work has been done at various times, it has been with variable success and as a rule with little profit. At present, aside from the desultory labors of a few miners who occasionally make fair wages, little work is being done on the deposits.

Hot springs.—On the east side of Soda Creek, about half a mile above its mouth, is a hot spring which has deposited grayish calc-sinter or travertine to a thickness of 4 or 5 feet. The lower several inches of this deposit are soft and heavily iron stained. Similar deposits cover the east bank of Soda Creek for several hundred feet to the north of the present spring. The gravel near the spring is cemented by the same calcareous material and closely resembles the conglomerates previously described. The temperature of the water, as observed in two short tunnels that tap the flow, is 106° and 110° F. According to Mr. J. R. Allison, however, water with a temperature as high as 121° F. was obtained from two wells sunk to a depth of 25 feet below the bed of Soda Creek.

Faulting.—Minor faults are frequent in the mines, but the cross faults rarely displace the veins more than a few feet. The greatest known displacement, that of the Little Mattie vein, where faulted by the "cross vein," is from 10 to 25 feet. In the Newhouse tunnel a small porphyry dike which cuts several pyrite and quartz veinlets is step faulted by a series

[a] Fossett, Colorado, 1880, p. 381.

of parallel faults with offsets of about 6 inches. A pegmatite dike 1 foot in width in the Silver Horn mine is similarly step faulted. As these transverse faults seldom cause difficulties in mining they are of little economic importance except when, as occasionally happens, they are themselves mineralized and their intersections with the main vein produce pay shoots.

Very well-marked and comparatively recent movements have taken place along some of the main veins and in some cases have crushed and mixed the ore with so much triturated rock and gouge that the resulting mass is of little value, although the uncrushed ore streak might have been worked with profit.

MINERALOGICAL CHARACTER OF THE ORES.

The chief gangue minerals accompanying the ores are quartz, siderite, barite, calcite, rhodochrosite, and magnesite. With the exception of quartz, which is the conspicuous gangue mineral of the district, these minerals are found only in rare instances and in small amounts.

The principal ore minerals found in the mines to the south and west of Idaho Springs are pyrite, galena, sphalerite, and chalcopyrite, and they are present in greatly varying proportions. The values are principally in gold, silver, lead, zinc, and copper. The gold, although sometimes free, is usually combined with pyrite and chalcopyrite. In the area to the north of Idaho Springs the ore is mainly cupriferous pyrite and quartz, while to the south and west of the town galena and some sphalerite usually accompany the pyrite and quartz in the gold-bearing ores. As in the ores of the Georgetown-Silver Plume area, the silver generally accompanies galena and sphalerite, and when in quantity is usually associated with tetrahedrite ("gray copper"[a]) polybasite, tennantite, or argentite. The galena is both argentiferous and auriferous, as is also the sphalerite to a much less degree.

In the vicinity of the Lamartine mine, which lies about halfway between Idaho Springs and Georgetown, the ores are chiefly silver bearing, and galena and sphalerite predominate. For example, in the Lamartine mine itself the ratio of silver to gold has averaged 68 to 1 by weight. East and northeast from the Lamartine the proportion of gold increases until some of the mines, which have cupriferous pyrite and quartz veins, such as the Centurion, produce practically no silver.

FORM OF OCCURRENCE OF THE ORE DEPOSITS.

Nearly all the ores occur along fissures which are younger than the porphyry, as well as the older rocks. Most of the prominent veins in the northeastern portion of the quadrangle are parallel to the porphyry dikes, either along the wall or a short distance away from the dike. This close relation of the vein fissures to the dikes may be due to the fact that the contact of the porphyry with the other rocks constituted planes of easy movement, and the intrusion of the dikes may also have made the adjacent rocks more susceptible to fracturing; or the veins may have followed the same planes of weakness, or planes of the same system, along which the porphyry dikes were earlier intruded. In a few cases, however, for example, in the Gomer and Centurion mines, the veins cut transversely across the porphyry dikes. The general trend of the main veins, as well as of the principal porphyry dikes, is from southwest to northeast.

The fact that the ore-bearing zone is coextensive with the belt of porphyry intrusion is significant.

TYPES OF VEINS.

The veins in the vicinity of Idaho Springs may be separated into several types dependent on the grouping of the separate fracture zones. One type consists of a single or several parallel well-defined veins. These usually occur along or near and parallel to the contact of porphyry and the older rocks. Another type has a main or master vein from which smaller veins and veinlets branch. These smaller veins may in turn successively subdivide

[a] The polybasite and tennantite are also called "gray copper" by the miners.

until they finally die out. There are also special cases of crossing or intersecting veins or lodes.

An excellent example of a branching lode is found in the Fraction-Kitty Clyde vein and branches. The first type is well illustrated by the Little Mattie-Newton vein. In the Little Mattie mine there are two porphyry dikes running parallel to one another or else one large porphyry dike which splits into two or more parts, separated by large masses of gneiss and pegmatite. The vein runs approximately parallel to the dikes, at some places entirely in porphyry and at others with pegmatite or gneiss on both walls. Minor veinlets or feeders enter this main vein at long intervals. Moreover, the main vein itself splits up at both ends into several strong but less productive veins, and these become an example of the branching type. The New Era and Great Western veins also run parallel to each other and are only about 75 feet apart. A minor cross vein intersects both of these parallel veins.

The crossing of veins is well illustrated by the intersection of the Black Eagle and Bismark veins.

PAY SHOOTS.

Junctions of two large veins or of branches or feeders with a main vein are frequently sites of ore deposition. Most of the ore in such cases is on the main vein, but some ore is also found along the cross or branch veins for some distance from the junction.

In veins parallel with and at or near the contact of a porphyry dike, pay shoots are sometimes found at the junction of minor branches, but they commonly occur irregularly along the fractured zone. This irregular distribution of the shoots may possibly be accounted for in the following manner. Porphyry or other wall rock, when intensely altered, often changes to a clay-like mass which is soft and tends to close up any fissures running through it. As this clay-like substance is practically impervious to the ore-bearing solutions, these solutions are diverted into the more open channels or spaces between the clayey portions and there deposit the ores. This deposition may be the result of mingling with other solutions or of replacement of the strained or crushed and pulverized rock along the fractured zone.

In the Little Mattie mine crushed pegmatite and gneiss zones are inclosed between two dikes of porphyry. As the dikes converge the "horse" of gneiss and pegmatite is gradually replaced by quartz and ore, until finally the space between the porphyry dikes is filled completely by ore and gangue material, no pegmatite or gneiss being visible. Somewhat similar ore bodies have been formed by the replacement of porphyry instead of pegmatite and gneiss. In such cases the vein, which is entirely in porphyry, splits and incloses a mass of porphyry 2 or 3 feet in diameter. This mass is composed mainly of crushed but comparatively unaltered porphyry; but in places this grades first into porphyry partially replaced by ore and quartz, and then into solid ore and quartz, showing no trace of the original porphyry.

The Little Mattie-Newton vein is crossed by several later and leaner veins. One of these, the so-called "cross vein," faults the Little Mattie vein from 10 to 25 feet. This vein, while carrying only low values itself, seems to bear a definite relation to the ore bodies, for a series of them are found to lie one above another immediately east of the "cross vein." The Chicago-Bismark and the Guy Irving veins likewise intersect the Little Mattie-Newton vein. The first of these, the Bismark, is crossed by the Black Eagle vein and is faulted by it about 6 feet. An ore body was found at this intersection. The Waltham-International and the Amethyst veins are examples of other large veins of comparatively little mineralization which cross the main belt of northeast-southwest veins.

PERSISTENCE OF FAULT MOVEMENTS.

Movements occurring after the solidification of the porphyry dikes caused fissures which contained loose angular fragments of porphyry and the older rocks. Subsequent deposition of ore in these fractures formed a consolidated breccia with the ore minerals constituting the matrix.

Movement has been renewed along the same vein fractures since the ore was deposited and has crushed the vein or the ore breccia just described into a secondary breccia of mixed ore and wall rock, and later solutions have cemented the fragments with silica. Comparatively recent movements have in turn crushed this second breccia and have left the fragments of ore, quartz, and country rock in an unconsolidated matrix of finely crushed and decomposed material. Some of the movements along the veins already referred to have been very pronounced, as is indicated by the well-rounded form and often polished surfaces of the pebble-like fragments filling the vein. Good examples of these friction conglomerates occur in the Stanley and Freeland mines and in the Newhouse tunnel. There is a breccia filling in the Stanley mine, however, which can not be ascribed wholly to movement, but rather to the filling by detritus of a water course along an open fissure.

The later movements also produced the transverse faults already described.

RELATION OF ORE DEPOSITION TO DEPTH.

Ore has been found as deep as 1,800 feet below the surface in the mines south and west of Idaho Springs. Most of the workings, however, reach a depth ranging from 100 to 800 feet.

In many of the mines the vein practically disappears at a variable depth from the surface, only an uncemented fracture or fault zone remaining. It is not, however, fair to ascribe this fact in all cases to direct dependence of the mineralization on proximity to the surface, for a similar decrease and practical disappearance of the mineralization is frequently encountered on following the vein horizontally. The fact is that the ores have been deposited in certain areas, limited in all dimensions, along the fault-zones. Such ore bodies may or may not now be exposed at the surface as a consequence of erosion subsequent to ore deposition. In the majority of cases they probably outcrop, but in some they do not. The Lamartine mine affords an example of an ore shoot that does not extend to the surface. Croppings of the vein gave assays of less than $4 to the ton and no ore was encountered until the ore body was reached at a depth of 100 feet below the surface.

On the whole there is no very striking or complete change in the character of the mineralization within an ore body from top to bottom. In several mines the ore at depths of from 800 to 1,600 feet is as rich as that near the surface.

ECONOMIC FEATURES OF NORTHERN IDAHO AND NORTHWESTERN MONTANA.

By D. F. MacDonald.

INTRODUCTION.

After the detailed study of the Cœur d'Alene mining district by Messrs. Ransome[a] and Calkins in 1903 and 1904, there remained an extent of country stretching a hundred miles to the north, the geology of which was comparatively little known. In order to investigate this field and correlate its rocks with the Cœur d'Alene sediments and the known rocks along the boundary and in northwestern Montana, a geological reconnaissance was ordered. This examination was undertaken by Mr. F. C. Calkins, assisted by the writer, in July, 1905.

A good idea of the location and extent of country covered can be had by following the route taken as it is traced on the accompanying map (fig. 2). Obviously only the main geological features could be observed in passing over so large an area within the time allotted. An endeavor was made, however, to visit mines and prospects wherever possible, although economic investigation was merely incidental.

PHYSICAL FEATURES.

The region investigated is a great succession of mountain peaks and ridges having an average altitude of 5,000 to 6,000 feet. A wide valley forms its western boundary and two large rivers, Clark Fork of the Columbia and the Kootenai, have trisected this extensive mountain region into three northwest-southeast mountain systems. A glance at the accompanying map will show the location of these systems, which are the Cœur d'Alene Mountains on the south, the Cabinet Range in the center, and the Loop Mountains on the north, the latter being subdivided into the Mooyie, Yaak, and Purcell ranges.

The Cabinet Mountains is the only one of the ranges in which rugged saw-tooth ridges, at some points over 8,000 feet high, occur. Here on the north slopes are still found a few small ice fields, remnants of a once extensive system of alpine glaciers.

GEOLOGY.

INTRODUCTORY STATEMENT.

Algonkian rocks prevail over a large area in northern Idaho, northwestern Montana, and southern British Columbia. The best known Algonkian rocks of this particular area are the mineral-bearing formations of the "Cœur d'Alene series," which forms perhaps the major portion of the Algonkian province. Within this area were also found some limy sediments of doubtful age.

Ripple marks and sun cracks show that these rocks were laid down in shallow water. No unconformity was seen throughout the 20,000 feet of their thickness.

Bounding this great Algonkian rock province on the west are Archean schists and gneisses. On the east are the middle Cambrian, Carboniferous, and Upper Cretaceous sediments of western-central Montana. The southern boundary is formed by the extensive body of intrusive rocks of central and southern Idaho. Toward the southwest lie the great lava beds of the Columbia plain.

[a] Ransome, F. L., Bull. U. S. Geol. Survey No. 260, 1904, pp. 274-303.

The Archean rocks, ancient looking and much metamorphosed, are separated from the later and fresher-looking Algonkian series by a great unconformity.

Younger igneous rocks have cut the sediments of the district as basic dikes and sills, and vast chambers have been stoped out and occupied by intrusions of granite.

In the structure of the district many large normal faults were noted. A few great folds were observed, but in general monoclinal blocks prevail.

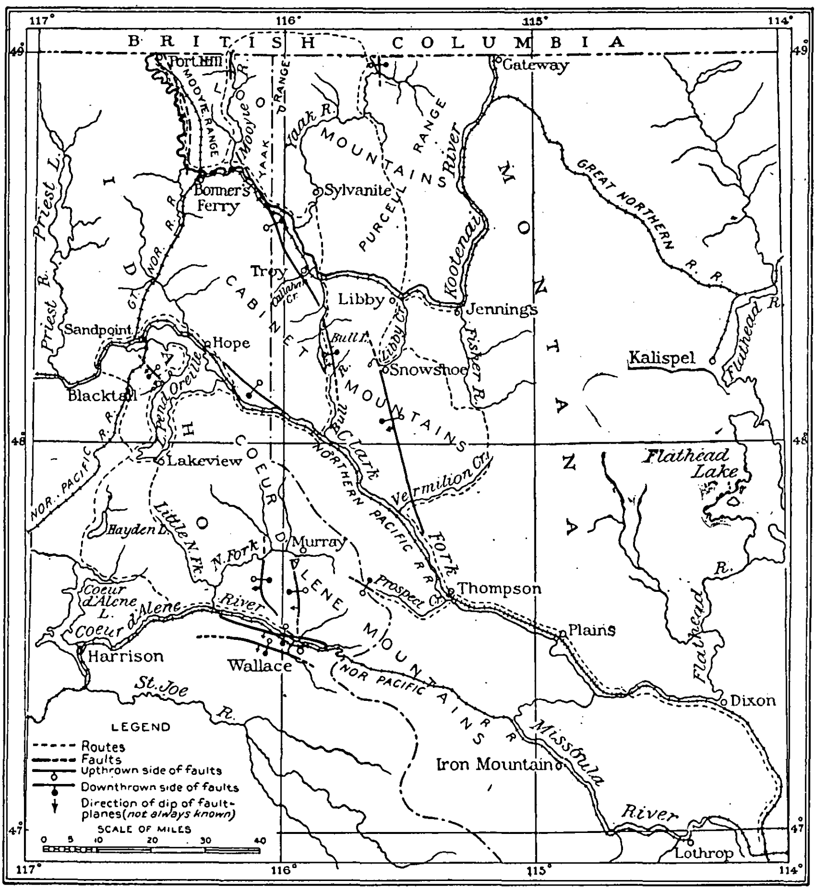

FIG. 2.—Outline map of northern Idaho and northwestern Montana.

STRATIGRAPHY.

ARCHEAN.

The Archean rocks are well shown on the west shore of Cœur d'Alene Lake. Here sediments, now in the form of highly crystallized schists, had been penetrated by numberless dikes and intrusions of granite, later changed to typical gneiss. These intrusions probably took place early in the geological history of the formation and long before extensive metamorphism crystallized the whole into its present form.

ALGONKIAN AND PALEOZOIC.

Cœur d'Alene section.—A good idea of the Algonkian formations of the district can be given by briefly describing the Cœur d'Alene series and using this as a basis of comparison for the other Algonkian rocks.

Tabular section of the Cœur d'Alene series.

No.	Name.	Description.	Approximate thickness.
			Feet.
6	Striped Peak formation....	Sandstones, siliceous, generally flaggy to shaly; colors mostly green and purple; characterized by shallow-water features, as ripple marks, sun cracks, etc.	1,000+
5	Wallace formation.........	Thin-bedded sandy shales, underlain by rapidly alternating thin beds of argillite, calcareous sandstone, impure limestone, and indurated calcareous shale; these underlain in turn by green siliceous argillites. Shallow-water features throughout. Slaty cleavage common.	4,000
4	St. Regis formation........	Sandstones, generally flaggy or shaly; usually fine grained and much indurated; colors mostly green and purple; characterized by shallow-water features.	1,000
3	Revett quartzite...........	White quartzites, generally rather thick bedded; interstratified with subordinate quantities of micaceous sandstone.	1,200
2	Burke formation...........	Gray, flaggy, fine-grained sandstones and shales, with interbedded purple quartzitic sandstone (the proportion varies widely in different parts of the district) and white quartzite. The formation characterized throughout by shallow-water features.	2,000
1	Prichard slate..............	Mostly blue-black, blue-gray to light-gray slates, generally distinctly banded. Considerable interbedded gray sandstone. Upper portion characterized by rapid alternations of argillaceous and arenaceous layers, and by shallow-water features. Base not exposed.	8,000+
			17,200

Modifications of Cœur d'Alene section.—Most of the beds forming this section vary greatly toward the north and east; some of them entirely disappear, others grow much thinner, and the remaining ones get somewhat thicker. Moreover, new rocks make their appearance both above and below the Cœur d'Alene series.

The rock which gradually takes the place of the Prichard slate toward the north is a gray, siliceous, fine-grained quartzite which weathers brownish gray. It is well shown north of Sylvanite and has been named Creston quartzite by Daly of the Canadian Survey. Toward the east, however, the Pritchard slate was observed to outcrop throughout the 30 miles between Plains and Dixon.

The Burke formation is essentially the same in composition throughout the district under survey. The Revett quartzite was not observed north of the Kootenai nor east of Missoula River. The St. Regis red and green beds were not well defined north of the Cabinet Mountains. Toward the east they were traced to Iron Mountain, Montana. The Wallace formation is much thicker toward the Cabinet Mountains. Here too, as well as toward the east, it contains a higher percentage of lime. What appeared to be Striped Peak sediments were found at intervals toward the north, but could not be definitely correlated.

Limestone beds of considerable extent occur around the south end of Lake Pend Oreille. They are thought to have been deposited later than the Cœur d'Alene rocks, but were not definitely correlated, as all their observed boundaries were faults or igneous rocks.

Above the Cœur d'Alene series a great thickness of green and gray argillaceous shales, overlain by limy brownish-yellow weathered argillite, has been developed. This is well shown in the Cabinet Mountains north of Bull Lake.

Other limestones occur between Libby and Jennings and on Swamp Creek southeast of Libby. These latter beds are quite pure and are associated with red and green shales. Near Lothrop, on Missoula River, limestone beds were also found, containing traces of what may be crustacean remains. More detailed study may prove these limestones to be of Cambrian or Ordovician age.

IGNEOUS ROCKS.

The igneous rocks of the district fall naturally into two general groups—"granitic rocks," and basic sills and dikes.

Granitic rocks.—A broad belt of intrusive granitic rock extends along the western boundary of the Algonkian area. Another large intrusion of granite is found just north of Bull Lake in the Cabinet Mountains, and a third great granitic mass outcrops in the basins of Lightning and Callahan creeks. A vast body of very hard, tough porphyritic rock, probably granite-diorite-porphyry, forms a mountain peak on the eastern shore of Lake Pend Oreille.

Basic sills and dikes.—The intrusive sills which sometimes occur in the bedding planes of the sedimentary rocks of the district are well shown at the mouth of Mooyie River and on the boundary 5 miles east of that river. Basic dikes also cut the formations in many directions and in some instances have mineral deposits associated with them.

Basalt.—Several large basalt terraces occur around the south end of Lake Pend Oreille. They are remnants of the great Miocene basalt floods which came in from the south.

QUATERNARY GRAVEL.

The Quaternary gravels are mentioned on account of their economic interest. They form extensive benches high above present river levels. Streams coming in contact with these benches have reworked the material and gradually concentrated the heavier metals in the gravel bars which formed in their channels. A few lean diggings of placer gold have been formed in this way, notably on Mooyie River and Vermilion Creek. Placer mining, however, has not been very productive in the district as a whole.

STRUCTURE.

FAULTS.

A glance at the accompanying map (fig. 2) will show the location and direction of the principal faults better than they can be described. The displacement in some of these normal breaks has been very great, upper beds having been brought into juxtaposition with beds formerly many thousand feet below them. The friction caused by these slips has formed shattered zones on each side of the fissure. Rarely a ridge of quartz-breccia marks a fault. Here the fragments have been cemented by silica-bearing solutions into a mass which successfully resists weathering. Oftener, however, the crushed fragments disintegrate and weather away, marking the break with a V-shaped valley. Oxidizing surface waters percolating freely through these fragments aid the prospector to locate the fault by marking it with an iron capping. These faults have a direct economic importance in that they formed channels of circulation in which the mineral-bearing solutions were able to deposit their loads. Thus were formed most of the present mineral veins of the district. It should be noted, however, that the large faults are not so apt to contain economic deposits as the smaller ones. This may be due to the great area of the large fault fissures and of their brecciated zones, which would render extremely difficult the collection by percolating waters of enough mineral to make an ore deposit. The Snowshoe fault is no exception to this, because, though very large, it is clearly cut and has no brecciated zone; hence the portion subject to mineralization is quite restricted.

MINERAL RESOURCES.

General statement.—To the northwest of the region under survey are the great mineral districts of Slocan, Arrow Lake, Lardeau, and Revelstoke, in southern British Columbia. To the southeast are the famous Cœur d'Alene silver-lead mines. Indeed, a fairly complete series of mineralized areas may be traced between these two mining districts. This connecting mineral zone may be observed on the northeast slope of the Cœur d'Alene Mountains at Prospect Creek. It continues across into the Cabinet Range at the heads of Fisher River and Vermilion, Libby, and Callahan creeks, and so northward into the Loop Mountains at Sylvanite. The Pend Oreille mineral area may be said to mark its western flank.

At different periods many small mining camps have flourished in this general region. Much development work has been done, but at present only one property is making regular shipments. Sufficient low-grade ore has been opened on several claims to encourage further work.

CHARACTER OF DEPOSITS.

Nearly all the metalliferous deposits observed in the region are veins which have been formed by filling fissures and replacing their walls. In some instances after the vein was filled movement again took place which slickensided the vein material. There are a few contact deposits of minor importance.

It may be noted that the base ore lies comparatively close to the surface in this region, and there is very little secondary enrichment or concentration of the leached-out surface values at depth. This may be accounted for by the rapid erosion which the surface rocks have undergone, particularly where glaciation has prevailed.

The only noteworthy nonmetalliferous mineral resources are some limestone beds from which lime is being manufactured.

DESCRIPTION OF DISTRICTS.

For convenience the economic deposits will be described by districts in the following order: Pine Creek, Lake Pend Oreille, Troy, Sylvanite, Snowshoe, Cabinet, and Prospect Creek.

PINE CREEK.

General features.—Pine Creek is about 6 miles west of the Bunker Hill and Sullivan and the Last Chance mines. It flows in a northerly direction into Cœur d'Alene River and drains a large wooded basin.

The country rock is Prichard slate and the veins are fissures which have generally been formed by faulting and which often have their walls partly replaced by vein material. The vein filling is white quartz and crushed country rock, the whole somewhat iron stained. The ore is a silver-bearing galena associated with zinc and some siderite and pyrite. The silver-lead values are low, and transportation charges are so high at present that mining for zinc, though the ore sometimes runs up to 20 or 30 per cent, is not profitable. The weathered zone of these veins was fairly rich in silver and lead carbonates to a slight depth, but the base ore was soon reached and development work was then usually suspended. Although much exploration work had been done in the district and considerable bodies of low-grade silver-lead-zinc ore found, very little mining activity was evident at the time of visit.

Mines and properties.—The Anderson group, 3 miles from the mouth of Pine Creek, has a few tons of rich-looking ore on the dump. A 60-foot adit and 20-foot winze are the extent of development work.

At the King property, a mile south of the Anderson property, a few tons of ore have been extracted from an 85-foot adit.

The Douglas, 6 miles south of the King, has had a considerable amount of development work done. Three hundred tons of ore are on the dump and about 10,000 tons in sight. The ore is peculiar in that it seems to be a fine-grained galena, carrying, it is reported, almost 30 per cent of zinc.

The Surprise, on another branch of Pine Creek, is about 2 miles southeast of the Douglas. A 450-foot crosscut adit taps the vein at considerable depth. It is said to give an average assay of 31 per cent lead, 30 per cent zinc, and 10 ounces of silver to the ton.

The Nevada Stuart is just across the creek from the Surprise, and is on the same northwest-southeast lead. A 300-foot adit constitutes the development work.

The Highland Chief, half a mile up the creek from the Nevada Stuart, has been the scene of considerable development work. It was reported that its past period of idleness had recently been broken by a shipment of two carloads of ore.

The Nabob, on Stone Creek, a tributary of Pine Creek, expected to ship four carloads of ore shortly.

Outlook for the district.—The mining future of Pine Creek depends on the discovery of some satisfactory treatment for saving and separating the silver, lead, and zinc values of the ores. Such treatment should enable the district to become an important producer, but under present conditions development on a large scale can hardly be expected from it as a whole. It is possible, however, that ore bodies may be uncovered which contain a minimum of zinc and sufficient silver and lead to become dividend payers even with present methods.

LAKE PEND OREILLE DISTRICT.

LAKEVIEW.

General features.—At the southeast end of Lake Pend Oreille, on a bench just in front of a high mountain, stands the little town of Lakeview. Although extremely quiet now it once gave promise of being a most active mining center.

In October, 1888, Messrs. Frederic A. Webber and S. P. Donnely came across from Eagle Creek, in the Cœur d'Alenes, on a prospecting trip. They made a discovery, located on it, and went back for supplies. They kept their secret well, but a suspicion of their find got abroad. On their return an eager throng followed them back over the mountains. That fall and winter over 2,000 people went into the new district and founded the town of Chloride. This town, of which there are now but a few tumbled-down shanties remaining, stood at a forks of the creek about 5 miles above the present town of Lakeview. The boom lasted about a year, and then the stampede element drifted away and only those who had faith in the district remained and continued a systematic development of their holdings.

Mines and properties.—The Webber group of claims lies about 6 miles south of Lakeview, from which place it is reached by a wagon road. The vein is a fault fissure in which the walls have been somewhat replaced by vein material. The fissure runs about east and west, and gives evidence of a considerable displacement. It is associated with a diabasic dike and cuts a country rock of Wallace shale.

On the surface, in the weathered zone, the ore carried free silver to a reported value of about 400 ounces per ton. This led to its acquisition by a company and the installation of a complete free-milling plant. Soon, however, the lead and silver appeared in the sulphide form, and the values could not be saved by such a process. Some shipments were then made to a smelter, but the ores were not of high enough grade to return a profit, and accordingly operations at the mine and mill were suspended.

The Keep Cool group adjoins the Webber property on the west and appears to be on the same vein. A section of the vein here shows a large zone of breccia, gouge, and quartz carrying considerable galena and striking about N. 75° W., with a dip of 75° S.

The Conjecture property lies a mile below the Webber, on the same creek. The country rock, vein, and ore are practically the same as those of the other mines. A free-milling plant was used for the treatment of the rich surface ores.

The Hidden Treasure claim is located on a fissure in limestone which is characterized by a fault of considerable displacement. It is being worked by an open cut which reveals galena of good quality. The Venezuela and Silver Chord had not, at the time of visit, produced any ore.

Production.—The following table shows the estimated amount and value of ore shipped from the district:

Table of ore shipped from the Lakeview district.[a]

Name.	Tons shipped.	Value per ton.	Remarks.
Webber group	Concentrates, 2,000; crude ore, 11,000; now on dump, 6,000.	Lead, $2; gold, $1.50; silver, 24 to 50 ounces.	Idle for some time; hope to resume work when new smelter is built at Sandpoint.
Keep Cool	To the value of about $15,000.		Not working.
Conjecture	To the value of about $70,000.		Do.
Vulcan	50		Do.
Hidden Treasure	50; on dump, 50	Average assay, $40	One man getting out ore.

[a] This table is based on data kindly furnished by Mr. F. A. Webber.

Outlook.—This district has been proved to contain considerable low-grade silver-lead ore. Under present conditions the operation of the many small properties of the district would be expensive. Cheap production is the question to be solved in this field. Consolidation of interests and work on a large scale would seem to be productive of the best results here and would very probably produce some good dividend-paying properties. The new smelter at Sandpoint will doubtless furnish a better market for the ores than has hitherto been available and will materially encourage further work.

Lime.—Most of the properties of the Washington Brick and Lime Company, of Spokane, are situated within the Lakeview district. A plant of four kilns at Squaw Bay, a few miles from Lakeview, is owned by this company. It has been running fifteen months and has turned out about 75 barrels of lime per day. This product is shipped on scows to Hope and thence to its destination by rail.

A large deposit of very pure gray limestone of uncertain age occurs close by. This deposit, together with others of the same nature which are found in the vicinity, can perhaps never be exhausted by lime-manufacturing plants.

BLACKTAIL MINE.

This property is on the northeastern slope of Blacktail Mountain, a high peak in the ridge which forms the southwestern shore of Lake Pend Oreille.

The vein is in Wallace shale, near to the large Blacktail fault, but is not very clearly defined. A good deal of development work has been done and considerable ore shipped in the past. No recent shipments have been made, however. It was reported that the ore was found in a narrow fissure and was quite rich in silver. Neither assays nor data regarding shipments were available at the time of visit.

EASTERN SHORE.

As the Lakeview district began to decline, the many prospectors it had attracted gradually scattered over the surrounding mountains. The result was that a great number of claims were staked on the eastern shore of Lake Pend Oreille. Many of these were abandoned, but a few are still being developed for their gold content; others are held as future producers of silver and lead. Perhaps the greatest promise, however, is attached to those being slowly developed for their copper values. In spite of the lack of concentrated development work, the district has some promise as a prospecting field and may yet develop shipping properties.

Prospects.—The June Bug is a claim on the east end of Lake Pend Oreille. It is situated a few miles southeast of the point where the Clark Fork empties into the lake. The country rock is green and purple shale. The vein is of white quartz running N. 75° W., with a dip of

80° S. It shows considerable specular hematite, a little bornite, and some chalcopyrite. Not enough development work has been done to disclose any mineralization of commercial importance.

The Pend Oreille copper properties are located near the Northern Pacific Railway, a few miles east of Hope. The country rock is a bluish-gray shale belonging to the Wallace formation. The main lead is about 11 feet wide, and its walls are fairly well defined. It seems to trend about N. 55° E. and to dip 80° E. The croppings show cupriferous pyrite, but the vein has not been sufficiently opened to reveal its extent and value.

TROY.

Troy is a small Montana town on the Great Northern Railway. It is in the Kootenai Valley, at the foot of the Cabinet Mountains, and is the natural distributing point for the mining properties on Callahan Creek and Grouse Mountain.

CALLAHAN CREEK.[a]

On Callahan Creek are two lead-zinc properties on fissure veins which promise to become producers of some importance. There is also a prospect farther up the creek than these, in what was considered by one observer to be a contact deposit. This, however, was not visited, so that attention may be confined to the two properties first mentioned, the Big Eight and B & B mines.

The ore bodies in which these mines are located occupy fissures, but igneous agencies have been concerned in their formation, and they have a composition characteristic of contact deposits rather than of ordinary fissure veins. The B & B and Big Eight are situated on the same fissure or on two parallel and only slightly separated fissures of the same system with a course of about N. 30° W. These breaks are subsidiary to a great fault which passes between the mines and Troy and brings Wallace and Striped Peak rocks on the east down against Creston quartzite and Prichard slate on the west. The country rock of the B & B mine is typical Prichard slate; that of the Big Eight is a grayish quartzitic material probably belonging to the Creston quartzite. Penetrating these sedimentaries and injected in the fissure occupied by the vein, there is in each of the mines a basic dike, so far altered that its original petrographic character can not be satisfactorily determined. The mineralization seems to have been posterior to, but was possibly in part contemporaneous with, the intrusion of the dike.

In the Big Eight mine the vein is just west of the dike. It is about 8 feet wide, with walls fairly well defined. The ore is rather irregularly distributed, in places forming most of the vein, but often mixed with much gangue material and masses of country rock. It is principally sphalerite, which forms large masses of great purity, but is locally mixed with a subordinate quantity of galena. The gangue is the most remarkable feature of the vein, and consists chiefly of silicates, including a pale-greenish amphibole, garnet, biotite, and chlorite. Calcite and a little pyrite occur locally. About 200 feet east of and parallel to the main vein is a small vein of nearly pure galena.

The B & B vein has practically the same characteristics as the main vein of the Big Eight. The gangue is likewise chiefly a mixture of silicates, and the valuable minerals consist of sphalerite and galena.

Neither property was shipping ore when visited, although both have shipped considerable amounts in the past. The B & B was idle, owing, it was reported, to litigation. The Big Eight was being worked under a lease held by the Batchelder Brothers of Spokane, and had about 150 tons of ore on the dump.

GROUSE MOUNTAIN PROPERTIES.

Grouse Mountain is a spur of the Cabinet Range, lying between the headwaters of Callahan and Lake creeks.

[a] This region was visited and described by Mr. Calkins.

The Great Northwestern property is situated on the southwestern slope of the mountain. The country rock is grayish siliceous shale, probably of the Prichard formation, which is cut by a large diabase dike trending northwest and southeast. A fracture zone parallel to and lying within this dike forms the vein. It is filled with white quartz, calcite, and iron-stained breccia, is from 2 to 6 feet wide, and carries galena, some iron pyrite, marcasite, siderite, sphalerite, and a few crystals of chalcopyrite. The ore is said to carry from 18 to 50 ounces of silver per ton and seems to occur in irregular bunches. The vein appears to be richer where it is cut by a porphyry dike of later origin. About 60 tons of ore are on the dump awaiting the construction of a wagon road to Troy, 12 miles distant.

The Iron Cap property adjoins the Great Northwestern and seems to be on the same lead, which here cuts typical Prichard slate. It has been opened up by a shallow open cut, exposing a large amount of iron capping and crushed vein material. Some pieces of galena are found throughout the less weathered parts.

FUTURE PROSPECTS.

Though comparatively young, the Troy district shows considerable promise. The veins seem to be strong and development work may show ore bodies of considerable extent. In spite of the fact that some of the ores carry zinc, wisely directed operations should produce some paying mines.

SYLVANITE.

Location.—Sylvanite is situated in the Loop Mountains on Yaak River, about 20 miles north of the point where it unites with the Kootenai.

Mines and properties.—The Keystone and Goldflint, situated on the same lead, are the two principal properties in the district. The country rock is Creston quartzite. In being folded to its present form certain hard beds have slipped over the softer beds. Between two such folded beds lies the vein, which has a filling of white quartz and iron-stained crushed rock.

The extent of the workings would indicate that the mine had produced considerable free-milling gold ore. This ore was concentrated in a 10-stamp mill. The property is now idle, owing, it is reported, to litigation. Base ore which could not be treated by the free-milling process, may, however, have been found with depth.

SNOWSHOE MINE.

General statement.—The Snowshoe mine, owned by the Rustler Mining and Milling Company of Pittsburg, comprises three patented claims, the Snowshoe, Rustler, and Porcupine. Information regarding the output, values, etc., of the mine was courteously afforded by the manager.

Location.—The Snowshoe mine is situated in the most precipitous and rugged part of the Cabinet Range. It is at the head of Libby Creek and just across the divide from Bull Lake.

A good wagon road down Libby Creek connects the mine with the Northern Pacific at Libby, about 22 miles to the north. Several four and six horse teams haul the ore out and bring in the supplies over this road.

Geology.—The Snowshoe vein occupies the fissure of a large, clean-broken fault. The country rock on the east side of the fault is a grayish-green to dark-gray massive shale of the Burke formation, and on the west side a calcareous shale of the Wallace formation. This shows that a throw of several thousand feet has occurred. Owing, however, to the fact that the fissure is here almost perpendicular, there has been a minimum of friction and very little gouge has been formed.

The vein is clearly defined, has almost perpendicular walls, and trends north and south. Another smaller vein lies about 75 feet east of the main lead and almost parallel to it. The filling material is principally white quartz and crushed rock, with a few inches of shiny black talcose parting on the east and a little greenish-blue gouge on the west wall.

Development work has opened up 300 or 400 feet of depth on the vein, showing lenticular masses of galena and an average width of about 7 feet.

Ores.—The ore is a silver-bearing galena, carrying a gold value of about $1.50 per ton, which is said to increase with depth. An average assay shows about 10 per cent lead and 5 ounces of silver per ton. This ore, concentrated approximately 6 or 7 into 1, yields about 50 per cent lead, 25 ounces of silver, and $5 to $10 in gold. In view of the long wagon haul it is very desirable that the concentration be carried as far as possible. This results in the loss of a large proportion of the gold values, probably as high as $400 per day. The mine has shipped to date about $850,000 worth of ore, mainly to the smelter at Everett, Wash.

Plant.—The concentrating plant is driven by water power, except the compressor and electric-light plant, which during the dry season are driven by steam.

The water power is now obtained by damming water in glacial cirques above the mine. This storage could be greatly increased and a considerable saving on steam thus effected by improving the position and increasing the size of the dams.

Future prospects.—This property is now the leading producer in the district, and it gives strong indications of a considerably increased output before long. The great lead on which it is located is traceable for some miles, and is being explored in several of the numerous claims staked along its course. If the present development continues, a branch from the main line of the Great Northern Railway may soon be warranted. Such a branch line could easily and cheaply be built up the gentle grade of Libby Creek. It would pass through excellent timber land and would greatly encourage mining in the district.

CABINET DISTRICT.

Location.—The Cabinet district lies in the Cabinet Mountains about 20 miles southeast of the Snowshoe mine. It comprises the properties on Silver Butte Mountain and those on the headwaters of Fisher River. The former are reached from Trout Creek, on the Northern Pacific Railway, by a wagon road about 15 miles long up Vermilion Creek. Entrance into the Fisher River country is by wagon road from Libby, some 25 miles to the northwest, its nearest railway point.

SILVER BUTTE MINE.

The Silver Butte property is located on a vein which strikes N. 60° W. and dips 30° S. and cuts across Silver Butte Mountain.

The country rock is blue Prichard slate carrying some beds of grayish arenaceous shale. The vein averages 10 feet in width, but an outcrop on top of the mountain shows white quartz to the width of 30 feet, which can be traced for about half a mile. The ore is composed of galena, which is scattered through lenses of white quartz. Some sections of the vein show only barren white quartz, crushed country rock, and gouge.

In a concentrating plant erected at a reported cost of $150,000, some ore has been milled. While temporarily closed down this plant was burned to the ground and the mine has since been idle.

Outlook.—This property is located on a strong quartz vein. The exploration work done has exposed values enough to indicate that systematic development work might open up sufficient low-grade silver-lead ore to make the property a regular producer. Several other locations are on what appears to be the same vein, but as yet little work has been done on them.

FISHER RIVER PROPERTIES.[a]

Just across the divide of the Cabinet Range, in the Fisher River drainage, about north of Silver Butte, is a group of properties which were once sufficiently productive to have led to the construction of three stamp mills, but they are now almost completely abandoned. None of them were entered in the course of this reconnaissance, but their general character was observed. The lodes are all in typical Prichard slate and have the form of blanket veins parallel to the stratification. The vein material is chiefly quartz, with pyrite and gold, forming a rather low-grade ore which has apparently failed to yield profits below the zone of oxidation.

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[a] Visited and described by Mr. Calkins.

PROSPECT CREEK.

Location.—Prospect Creek heads in the Cœur d'Alene Mountains near Thompson Pass. It flows into Clark Fork near Thompson Falls, and is just across the divide to the northeast of the Cœur d'Alene mining district.

Mines and properties.—The Rosebud Mining Company is exploring several claims near the mouth of Rosebud Creek, a small tributary which enters Prospect Creek about 9 miles above its mouth. A vein of white quartz has been found by this company in the upper part of the Prichard formation. One of the owners reports that it carries some silver chloride and over $100 per ton in gold in the weathered zone at the surface.

The Montana Standard group of four claims is on Prospect Creek about 11 miles above its mouth. The vein is associated with a massive basic dike which cuts a country rock of the Burke formation. An adit driven on the east contact of this dike shows irregular masses of white quartz carrying galena. About 400 feet from the mouth of this tunnel a fairly well-defined cross lead runs N. 20° E. and dips 70° E. It shows some evidence of shearing and carries galena and siderite. On the west side of the dike a flat vein outcrops. It is 3 to 4 feet thick, strikes about N. 15° E. and dips 15° W. No connection between this vein and the ore deposit on the east side of the dike was apparent. The ore seems to lie in irregular bunches and cross fissures along the east contact of the dike. The examination of this property was very hurried, but it would seem advisable in the course of the present active development work to explore the east contact of the dike.

A few miles farther up Prospect Creek an antimony vein occurs from which a considerable amount of ore is said to have been shipped some years ago. This property is now idle. Other claims have been located on this creek, but very little development work has been done on them. A wagon road to Thompson Falls and Murray furnishes convenient access to the region.

MINING PROPERTIES NOT VISITED.

The Buckhorn, a few miles east of Mooyie River and about 10 miles above its mouth, is a producer of gold and shows some lead. So far as present development has gone the ore is free milling. A 10-stamp mill has recently been installed and shipments were expected to begin shortly. Some copper properties were reported to have been prospected at the headwaters of Bull River, but very little actual development work has been done on them. On Rainy Creek north of Libby is a prospect in a contact deposit from which some fair samples of galena have been taken.

MISSOULA VALLEY.[a]

The valley of Missoula River below Missoula has been and is still, though perhaps to a lesser extent than formerly, the scene of considerable mining activity. Large amounts of gold have been taken from placers on the tributaries. Copper deposits are being developed in the mountains south of the river, but their future value can not as yet be predicted with confidence. North of the river the veins are chiefly of galena, but few of these have been developed. The only property visited was the Iron Mountain mine, situated about 5 miles north of Iron Mountain station on the Northern Pacific Railway.

IRON MOUNTAIN MINE.

This property, once the most important in the district, is now idle. It began to produce about fourteen years ago and was worked for about eight years, during which period it yielded about half a million dollars in dividends besides paying the expenses of mine development, the building of a 200-ton mill, and the construction of about 15 miles of mountain road. The closing of the mine was due to the enactment of a State law which requires that every mine shall have two openings. It has now been determined to comply with this law by the construction on the 1,500-foot level of a tunnel which will be over a mile in length.

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[a] Visited and described by Mr. Calkins.

The surveys for the tunnel have been completed, and its construction actually begun, so that in the near future the mine will probably resume its place as a producer.

The ore body is a fissure vein about 3 feet in average width, striking about northwest and dipping steeply to the northeast. The country rock is somewhat calcareous light-green shale of the Wallace formation. The ore is argentiferous galena with a little sphalerite carrying about 6 ounces of silver to the ton. The concentrates constitute about 45 per cent of the ore as mined.

SUMMARY.

In regard to the region as a whole, the similarity of its rocks to those of the Cœur d'Alene district, together with its position between that district and the great producing mines of southern British Columbia, may well mark it as a promising field for the prospector. Moreover, large faults and their accompanying smaller fractures afford great systems of circulation for underground waters and greatly increase the opportunities for ore deposition in those fissures which present the proper conditions. Dikes, which in other mining regions have also been recognized as indicative of mineralized conditions, are abundant.

In conclusion, the reconnaissance has left a strong impression that systematic and wisely directed work in this region will yield good results.

NOTES ON ORE DEPOSITS OF SOUTHWESTERN NEVADA AND EASTERN CALIFORNIA.

By Sydney H. Ball.

INTRODUCTION.

During the summer and fall of 1905 topographic parties under Mr. R. H. Chapman made a reconnaissance topographic map of an area in southwestern Nevada and eastern California. The writer was attached to the parties as geologist, under the general supervision of Mr. F. L. Ransome.

The topographic map is on a scale of 1:253,440 (4 miles to the inch), with contour intervals of 100 feet, and covers the area lying between 36° 30′ and 38° north latitude and 116° and 117° 30′ west longitude. This area, embracing within its limits 8,550 square miles, is the equivalent of nine of the usual 30-minute quadrangles of the Geologic Atlas of the United States.

The territory surveyed was so great that in many cases only the most hasty examination of a single group of claims in a district was possible, and naturally an attempt was made to select representative groups. But little mining development has as yet been done, and extensive underground workings were nowhere accessible. With few exceptions, the rocks, fossils, and ores have not been examined in the office and the names employed are wholly tentative. The assay values given are those reported by the prospectors, and in most cases represent picked samples. A forthcoming bulletin on the geology of the area will be accompanied by adequate maps outlining the areas especially favorable for prospecting.

GEOGRAPHY.

The area surveyed lies in the Great Basin, and includes portions of Esmeralda and Nye counties, Nev., and Inyo County, Cal. The mountain ranges of the eastern portion of the area have a north-south trend, while the Panamint and Grapevine ranges in the western portion course north-northwest, more nearly parallel to the crest line of the Sierra Nevada. The highest peaks reach an altitude of over 9,000 feet. Between the mountains are broad inclosed valleys, covered by recent sands and gravels. Most of these valleys are from 3,000 to 5,000 feet above sea level, but that portion of Death Valley which lies within the area covered by the map sinks to 280 feet below sea level.

Tonopah, a prosperous mining town and the county seat of Nye County, lies 4 miles north of the area, and is the shipping point for some of the northern and northeastern camps here described. The central portion is tributary to Goldfield, where there are valuable gold mines. This town has 6,000 to 8,000 inhabitants, and is the present railroad terminus. The southern camps have the sister towns of Bullfrog, Rhyolite, and Beatty as supply points.

Goldfield and Tonopah have broad-gage railroad connections with the Union Pacific Railroad. The Carson and Colorado Railroad is from 25 to 45 miles west of the area's western border, and the San Pedro, Salt Lake and Los Angeles Railroad lies 40 to 75 miles east of its eastern border. A railroad has been surveyed from Goldfield to Bullfrog, and two roads are projected from the San Pedro, Salt Lake and Los Angeles Railroad to the same point.

ECONOMIC CONDITIONS.

The various camps herein described, the locations of which are shown on the sketch map, fig. 3, are connected with the supply points by wagon roads, most of them surprisingly good, considering the fact that many are less than a year old. Some mines have a small, but for the present sufficient, water supply near at hand. Other camps are compelled to haul their water from seeps 20 miles distant. Piñon and juniper grow sparsely

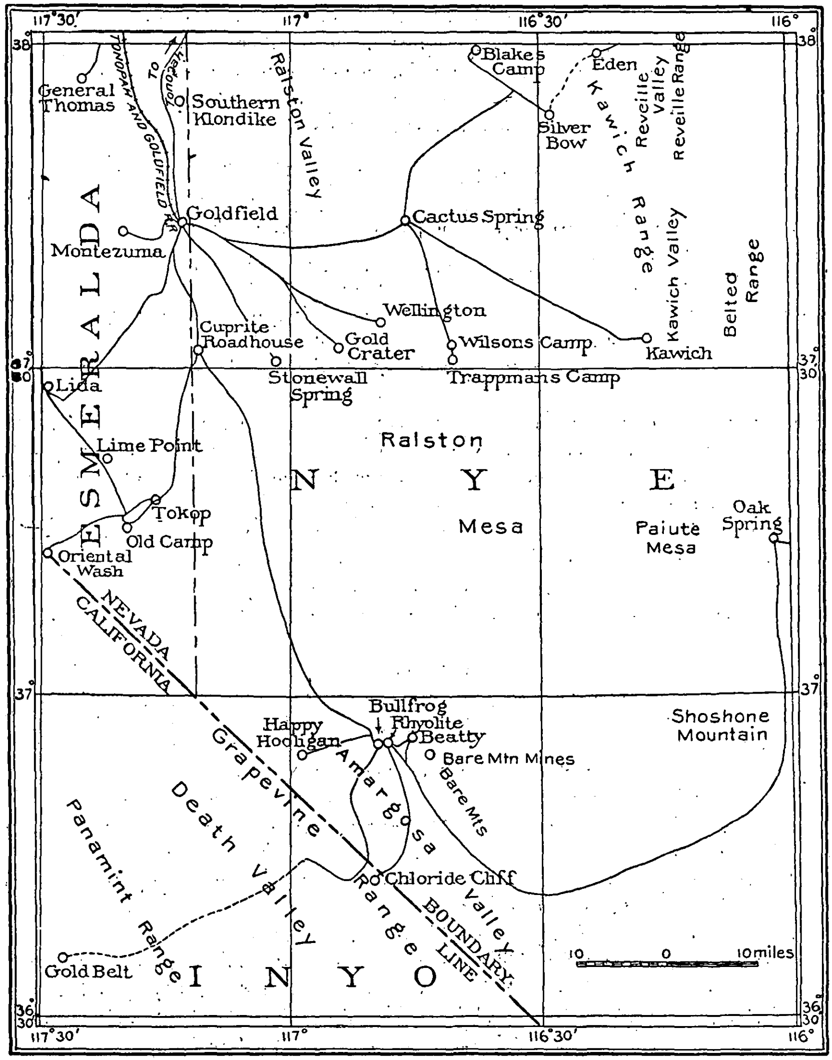

FIG. 3.—Sketch map of southwestern Nevada and eastern California, showing location of mining camps.

above an altitude of 6,000 feet. They are rarely of sufficient size for mine timbers other than stulls, but the former makes an excellent fuel. The power question will probably be solved at the successful camps, as it has been at Goldfield, by the transmission of electric power generated on the swift streams of the Sierra Nevada. The heat of July and August renders surface work almost impossible in the more southern camps.

GENERAL GEOLOGY.

The barest outline of the geology will be sufficient for present needs. Sedimentation, with few important breaks, extended from the Cambrian period to the end of the Carboniferous. The rocks appear to have been predominantly deposited in rather shallow seas, and include limestones, usually dark in color, quartzites of medium grain, and shales, often olive-green in color. In probably post-Jurassic time these rocks were injected by granites, now widely distributed throughout the area, and diorites, which are largely confined to the western portion. The age difference between these holocrystalline rocks is not great, and there is evidence which points to their possible origin by differentiation from a common magma. Contemporaneously with the intrusion mountains were formed or possibly preexisting mountains were elevated. The intrusion was accompanied by buckling of the strata, reversed faulting, and considerable metamorphism of the sedimentary rocks near the granite contact.

During the latter part of Mesozoic time the mountains were subjected to long-continued erosion, and at the end of the period surface irregularities were undoubtedly less accentuated than now.

In Tertiary time a long period of volcanism was inaugurated. Rhyolite and andesite in flows, sheets, and dikes followed one another repeatedly. Tuffaceous facies are rather common. Possibly in Miocene time considerable portions of the lower regions were covered by lakes which were contemporaneous with basalt flows. Then rhyolitic and andesitic eruptions followed. The Tertiary eruptions were accompanied by subaerial erosion, normal faulting, tilting, and flexing.

In recent time erosion has continued and great thicknesses of gravel and sand have been washed into the valleys as a result of cloudbursts, filling the inclosed basins as we now see them.

The ore deposits so far as known occur in the Paleozoic sedimentary rocks, the granite and diorite, and the older Tertiary eruptives.

HISTORY OF MINING DEVELOPMENT.

Two waves of activity in prospecting have passed over the portions of Nevada and California under consideration. The first started in the late sixties, reached its maximum height in the seventies, and died out before 1890. The hardy prospector and miner in these years confined his attention to the limestone and granite. Lida, Old Camp, and Montezuma were flourishing mining centers.

Mining in the areas studied was dormant in the nineties, but with the discovery of Tonopah's phenomenal ore bodies in 1900 the desert region was attacked with new ardor. The Tertiary eruptives have been more especially the chosen field of the prospector, although the limestones and granites have been by no means neglected. Goldfield and Bullfrog, the most important new camps, are now being studied in detail by Mr. F. L. Ransome and his assistants, Messrs. Emmons and Garrey, and will be the subjects of future Survey publications. Notes on the outlying districts only are embodied herein.

GENERAL CHARACTER OF THE ORE DEPOSITS.

The ore deposits herein described are apparently the work of two distinct main periods of mineralization—one post-Jurassic and probably pre-Tertiary, the other Tertiary. The veins at Chloride Cliff may, indeed, be even pre-Jurassic, but their resemblance to the post-Jurassic veins renders this questionable.

POST-JURASSIC AND PRE-TERTIARY DEPOSITS.

Deposits in granite.—(1) Pegmatitic dikes: Dikes of pegmatite at Oak Springs are reported to carry gold and silver values.

(2) Reopened pegmatitic dikes: The quartz, itself of pegmatitic origin, has been crushed, and the values are probably due to the same period of mineralization as that which formed the deposits next described (3). The deposits at Lime Point and some of those at Trappmans Camp are of this origin.

(3) Massive quartz veins in fissures, joints, and irregular zones of brecciation: The quartz is not crustified. The chief sulphide is pyrite, although galena, chalcopyrite, and sphalerite sometimes occur. The deposits are usually gold bearing, although with the introduction of galena silver values may predominate. These ores were deposited by water, which may have been remotely connected with the granitic intrusion. Such appear to be the deposits at Old Camp and some of those at Trappmans Camp, Oak Spring, and Southern Klondike.

(4) Impregnation of pyrite along joints: This is an unimportant form of deposit and is seen only at Trappmans Camp.

Deposits in diorite.—(1) Quartz veins: This is the type of deposit at Gold Belt, and is similar in form and mineral paragenesis to the deposits described in the next paragraph.

Deposits in Paleozoic sedimentary rocks, predominantly limestone.—(1) Quartz veins and irregular masses occupying faults, joints, bedding planes, and brecciated zones, usually in the neighborhood of granitic intrusions. Rarely a little calcite is associated with the quartz. The original sulphides deposited in the quartz include chalcopyrite, galena, pyrite, and sphalerite. In the veins in limestone the predominant sulphides are chalcopyrite and galena, and the values are largely silver. In quartzite and schist, in lime-silicate rocks, composed of quartz, garnet, and epidote, and in limestone zones in which silicification extended beyond the quartz vein, pyrite is the predominant sulphide, with gold values alone or in excess of silver. It is probable that the relative abundance and variety of sulphides was determined by the wall rock, the more siliceous rock tending to precipitate from the waters auriferous pyrite, the calcareous rock precipitating argentiferous galena and chalcopyrite. The secondary ores of this subdivision include malachite, azurite, chrysocolla, native copper, brochantite, cerussite, native gold, and horn silver, while chlorobromides of silver are reported. Chalcocite is probably of secondary origin. Two or more of these ores are associated with hematite and limonite or with a heavily stained jaspery quartz with conchoidal fracture. Gypsum and at one place sulphur are gangues of less wide distribution. Cavities in the secondary ores are often frosted by later quartz crystals. The Tokop veins belong to this subdivision, and their similarity to veins in the granite of Old Camp and their reported passing into the granite beneath indicate that the quartz veins in the granite and limestone are contemporaneous in age and of like origin. The Lida, Bare Mountain, and Oriental Wash deposits and some of those of Chloride Cliff, Montezuma, Oak Springs, and Southern Klondike are of this type.

(2) Veins following contacts. These occur in limestone along diorite-porphyry dikes and sheets and at Chloride Cliff along a mass of hornblende-gneiss. The diorite-porphyry is, without much doubt, pre-Tertiary, and the mineral association so similar to that in the deposits just described (1) that there can be but small doubt of the contemporaneous origin of the two from the same waters. The General Thomas and some of the Montezuma prospects are of this type.

(3) Replacement deposits: In the Cuprite mining district and to a less extent in the General Thomas mine the sulphides appear to replace the limestone in irregular masses. The Cuprite deposits are at a considerable distance from the granite masses, and in these deposits quartz is rare. The same secondary minerals are found here as in other deposits in the sedimentary rocks.

TERTIARY DEPOSITS.

Gold deposits in silicified monzonites.—Gold occurs at Kawich and Gold Crater in silicified and kaolinized monzonitic rocks. When the monzonitic rock was silicified pyrite was deposited in open fissures in it, and probably partially replaced the monzonite. Disseminated pyrite occurs beyond the silicified zone. During the surface alteration of the pyrite free gold lodged in the cavities of the altered monzonite and at Gold Crater was deposited along joints in the surrounding iron-stained monzonites.

Deposits in rhyolite.—(1) Silver and gold bearing quartz veins in silicified and kaolinized rhyolite: At Silverbow, Eden, Cactus Spring, Wilsons Camp, Stonewall Mountains, and Wellington vuggy quartz veins, often with crustification well developed, fill fault fissures, joint planes, and cavities of brecciation and solution. These deposits, if not demonstrably of contemporaneous origin, were formed by similar solutions. The original sulphides include stephanite, iron pyrites, and chalcopyrite. Pyrargyrite, also noted, may be secondary. From the primary ores free gold, horn silver, malachite, azurite, limonite, and hematite are derived. The relative abundance of silver sulphides or of pyrite determines whether the veins carry predominant silver or gold values. In the same camp structurally similar veins carry, respectively, gold and silver, and in various portions of the same vein the proportion of the two metals varies greatly. These deposits are evidently the work of ascending waters, which deposited quartz and sulphides in open crevices. The silicification and mineralization extended in many instances beyond the walls of the crevices.

(2) Gold ores in fault zones: At Blakes Camp free gold has been panned from crushed rhyolite along a fault. The iron pyrite was probably originally disseminated in the crushed zone.

(3) Gold ores along Tertiary lava and limestone contacts: A quartz vein at Southern Klondike is situated along the contact of rhyolite with Cambrian limestone. At the Happy Hooligan mine free gold occurs in decomposed rock at the contact of basalt with Ordovician limestone.

Relative ages of the Tertiary deposits.—It is believed that the first two subdivisions of the ore deposits in rhyolite are contemporaneous, while the third may be so also. The relative ages of the deposits in monzonitic rocks and rhyolite are unknown The monzonite is older than the rhyolite, but the deposits may be of approximately contemporaneous age.

DESCRIPTION OF CAMPS.

The description of the camps is arranged by counties, since in many camps several types of ore deposits occur. The mines of Esmeralda County are described in order from north to south. In Nye County the mines of the Kawich Range (Silverbow, Eden, Blakes Camp, and Kawich) are first described; then those of the Cactus Range (Cactus Spring and Wellington); next those of the Ralston Mesa (Trappmans Camp, Wilsons Camp, and Gold Crater), and lastly the remaining camps in the county.

ESMERALDA COUNTY, NEV.

Foothills of Lone Mountain.—In the northwest corner of the area surveyed and separated from the main mass of Lone Mountain to the northwest are hills whose borders are cut by narrow canyons. The Cambrian limestones and shales are here complexly folded, although the major folds have axes coursing from northeast to southwest. The sedimentaries are cut by irregular masses of diorite and by dikes and sheets of diorite-porphyry.

When visited by the writer in June, 1905, the General Thomas mine, of the Tonopah-Belcher Mining Company, was closed down. Several inclines follow the steeply dipping beds of limestone and shale, which in the vicinity are injected by sheets of diorite-porphyry. Cerussite, malachite, azurite, and chrysocolla in altered limestone heavily stained by limonite were seen on the dump. Gypsum was simultaneously formed with the secondary minerals. Galena and pyrite in calcite were the only original sulphides seen, but some copper sulphide must also occur. Mr. Arthur Lakes[a] states that lenticular bodies of "sand" carbonate of lead containing nodules of unaltered galena lay along the contact of porphyry and limestone, as well as in the limestone itself. The ore is said to carry high silver values. A carload shipment made in January, 1904, netted $4,300. At that time the shaft was 150

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[a] Min. and Sci. Press, vol. 88, p. 246.

feet deep. This deposit resembles some of those at Montezuma. Other prospects occur in limestone and in the diorite in the vicinity. The surrounding hills are bare of timber, and water is scarce. Tonopah, the supply point, is 12 miles distant by road.

Southern Klondike.—Southern Klondike is 12 miles north of Goldfield and an equal distance south of Tonopah. Gold and silver ores were discovered here in March, 1899, by Messrs. J. G. Court and T. J. Bell. Work has been carried on more or less continuously since that date. From one group of claims shipments of ore averaging $200 a ton and aggregating $50,000 are reported. Several thousand feet of tunnels, shafts, and inclines have been driven. In June, 1905 (the time of the writer's visit), eight men were at work in the camp.

The hills surrounding the camp are cones and ridges of low relief. The predominant formation is a black Cambrian limestone, locally silicified to a dark jasperoid. Associated with this are minor quartzite lenses and beds of partially metamorphosed shale. The sedimentaries are folded into an anticline with a northeast-southwest axis. While some vertical beds occur, moderate dips predominate. Small dikes and irregular masses of muscovite granite inject the Cambrian rocks. The granite is probably of post-Jurassic age. Tertiary flows and dikes of rhyolite respectively cap and cut the sediments.

The ore deposits are of three kinds—first, quartz veins parallel to the bedding of the Cambrian rocks; second, quartz veins carrying predominant gold values along the contact of the sedimentaries with quartz-rhyolite dikes; third, quartz veins in granite along joint fractures. The last-named veins carry silver-bearing lead ores (galena and cerussite). The contact veins show post-mineral faulting.

The quartz veins parallel to the bedding planes of the limestones are of greatest value and interest, and these only will be described. They are tabular lenses of quartz from a few inches to a foot or more in thickness. Horses of limestone are included. Adjacent veins connected by cross veins of quartz or completely separated by thin bands of limestone may form a mineralized zone 14 feet thick. The quartz appears to have filled a fissure in the limestone. Brecciation of the limestone accompanied the fissuring. The contact between the limestone and quartz is sharp, and silicification of the limestone has not occurred to an important extent. Vugs lined with quartz crystals are rather characteristic of the white, semitransparent quartz.

The original sulphides deposited simultaneously with the quartz and disseminated in small masses in it are, in the order of their abundance, galena, stetefeldite,[a] and iron pyrites, The secondary ores include horn silver, chrysocolla, malachite, azurite, specular hematite, and cerussite in brownish granular masses and to a less extent in crystals. These secondary minerals surround the sulphides and fill cavities and cracks in the quartz. Some calcite and gypsum, accompanied by sulphur, are secondary gangue minerals. Sulphur sometimes forms masses 3 inches in diameter. Assay returns show from 25 to 40 per cent of the values in gold, the rest in silver. Silver occurs as the chloride and apparently also associated with the copper minerals. The prospects as yet are well above water level.

In southern Klondike fissures and brecciated zones were opened in the Cambrian limestone along bedding planes. Water filled these cavities with silica and with lead, copper, and iron sulphides carrying silver and gold. The quartz veins have since been fractured and faulted and surface waters have developed a number of secondary minerals. In this district the presence of quartz veins at the contact of rhyolite and limestone shows the Tertiary or post-Tertiary age of the gold veins, but the presumption is that the more important silver veins are of earlier formation.

Water is obtained at the Klondike wells 4 miles distant. When visited, Tonopah was the supply and shipping point.

Montezuma district.—Montezuma is situated 8 miles nearly west of Goldfield. The Montezuma mining district was organized in 1867, and soon afterwards several mines were opened in the country west of Montezuma Peak. In the eighties a mill was erected in

[a] Copper-silver sulphide reported by J. E. Spurr: Trans. Am. Inst. Min. Eng., 1905, p. 961.

the gulch to the northwest of the mountain. Active work ceased in 1887, but at present a number of prospectors are reopening old properties and locating new claims. The district product, estimated at $500,000, was freighted in wagons to Belmont, 65 miles away. At present only a few shallow prospect holes and the dumps of the old mines are accessible for examination.

The Montezuma hills are a rugged spur of the Silver Peak Range, the highest point being Montezuma Peak. The mineralized area lies to the west of this mountain in Cambrian sedimentary rocks. Compact, fine-grained, black limestone, intimately cut by quartz and calcite veinlets, predominates over light-colored quartzites and green shales. The Cambrian is cut by diorite-porphyry and quartz-latite dikes. The folding of the sedimentary rocks is rather gentle, although local buckling of the strata is observed. The productive area is surrounded by nonmineralized Tertiary lavas and sediments.

In the old mines the chief gangue is quartz, with rarely a little calcite and kaolinitic material associated. Vugs filled with quartz crystals occur in the quartz. The ores at the surface are cerussite, malachite, azurite, and limonite, and associated with these and replacing them in depth are galena, chalcocite, and pyrite. The values are largely in silver, the gold values being uniformly low. Chlorobromides of silver are reported, but were not seen.

A prospect hole exposes a quartz vein with a diorite-porphyry dike as hanging wall and limestone as foot wall. Chalcopyrite is the original sulphide, and malachite with less limonite, azurite, and a little native copper are the secondary ores. The native copper forms knife-edges in cracks and small nodules in the vein. Malachite partially replacing limestone was noted at a number of other places.

Copper and lead sulphides with quartz fill open fissures in limestone. Some, probably all, of the deposition followed the dike injection, of probably pre-Tertiary age. Later the veins were crushed and surface waters altered the sulphides to carbonates, oxides, native metals, and probably minerals of the haloid series. That the chemical breakdown of the sulphides is continuing is indicated by the water flowing from an abandoned tunnel southwest of the mill; this deposits considerable limonite and is so charged with ferrous sulphate that animals will scarcely drink it.

In several of the older mines and prospects, water, some of which is suitable for domestic purposes, was encountered at a depth of 30 feet. The mines will probably require pumps, but abundant fuel surrounds them. Goldfield, the railroad terminus, is 9 miles distant, the road being fairly good.

Cuprite.—The copper prospects of the Cuprite mining district lie in a belt 1 mile wide which extends from a point 17 miles south of Goldfield westward to Mount Jackson. The district is a new one, the first locations having been made early in 1905. The mines lie from 2 to 9 miles west of the stage and automobile road between Goldfield and Bullfrog.

The low hills in which the mines lie are composed of Cambrian sedimentary rocks and flows of later eruptives. The Cambrian rocks are, as usual, predominantly limestones of black color and rather fine grain, and subordinately green shale, often paper thin, with semischistose facies. The limestone and shales are gently folded, the predominant dip being westward. Minor normal faults, in some instances intimately connected with the ore deposits, are common. The Cambrian at Cuprite, as at Lida, is cut by dikes of diorite-porphyry. Here also these appear to have no intimate connection with the ore deposits. To the north of the copper belt rhyolitic rocks cover considerable areas. Residual areas of later basalt flows of no economic importance cover both the Cambrian and rhyolite at a number of localities.

The properties of the Goldfield-Midway-Bullfrog Mining Company and the Tri-Metallic Mining Company may be taken as types of the copper properties of the Cuprite mining district.

The Copper Bell shaft of the first-named company is located on the side of a gentle valley in Cambrian sedimentary rocks and is now 85 feet deep. The shaft is being sunk to encounter a vein which strikes N. 60° E. and dips from 80°–85° NW. This vein has been traced by means of prospect holes at least 1,000 feet. At one prospect hole the vein is capped by a gossan of spongy limonite 9 feet thick. At this depth some malachite and less azurite are associated with the limonite, and at the bottom of the hole, 9 feet deeper, the vein is reported to have run 12 per cent copper, with 14 ounces of silver and $1.20 in gold per ton. The vein is from 2 to 5 feet wide and on its borders shows a gradual passage from totally unaltered limestone to pure limonite. These secondary ores, on the border of the vein, at least, are a replacement of the limestone. The same company has an incline 65 feet deep situated on a shear zone in practically horizontal limestone. The shear zone strikes N. 85° E. and dips 60° S. A streak of ore, traceable more or less continuously for 900 feet and from 1½ to 2½ feet wide, occupies the shear zone. The ore consists of malachite, azurite, and limonite, associated with intensely limonite-stained chalcedony of conchoidal fracture. The sulphides seen were chalcocite and, in less amount, chalcopyrite and pyrite. The two latter are undoubtedly original. Several assays of the ore are said to have averaged between 9 and 10 per cent of copper, while the silver values are variable, reaching as high as 400 ounces per ton. The silver is evidently intimately associated with the copper minerals, the iron compounds giving no silver returns. The average ore runs, per ton, about 1 ounce of silver to 1 per cent of copper. Gold is present in traces only. Another prospect on this property is in limestone much stained by limonite. Malachite and less azurite with a heavily limonite-stained chalcedonic quartz occur in small "kidneys" throughout the limestone and in narrow seams along joint planes. Chalcopyrite is reported from the surface here, but is not abundant. In another prospect irregular lenses of the same ores and gangue lie in a narrow shear zone in the limestone. Small bunches of chalcopyrite are sporadically distributed in the dark chalcedony.

The property of the Tri-Metallic Mining Company lies one-half mile west of that last described. The Cambrian limestone, although gently flexed, is approximately horizontal. Intense staining by limonite is characteristic of limestone in the vicinity of the ore. Minor faults were noted, but their association with the ore deposits is not intimate. A shipment of picked ore, which netted $236 per ton (averaging 7 ounces of gold, 230 ounces of silver, and 19 per cent of copper), was recently made from a surface pocket of ore. Chalcopyrite is the only original sulphide present. Chalcocite, malachite, and azurite with dark-brown chalcedony are secondary and these are partially at least replacements of limestone. A few masses of native copper, presumably of secondary origin, are also reported, although they were not seen by the writer. Chalcopyrite was apparently originally distributed in the limestone in masses, which so far as known do not exceed one-half inch in diameter. Later these scattered particles were concentrated, the secondary copper minerals apparently being replacements of limestone.

In the main shaft bunches of chalcopyrite lie in the limestone in association with coarse calcite much stained by limonite. In some cases the chalcopyrite has been brecciated and the narrow interstices filled with iron-stained chalcedony. The ore in this shaft is said to have occurred in "kidneys," sometimes connected with other "kidneys" by narrow ore seams. From one of these masses 1,900 pounds of ore were removed. This lens of ore was 4 feet in diameter at the center and tapered to a point at each end, the total length being 9 feet.

Ore examined from a claim owned by Mr. E. Oldt showed similar characteristics, a little galena and white quartz of apparently equal age being associated with pyrite and chalcopyrite. Again, transparent drusy quartz crystals contemporaneous with or later than the copper and lead carbonates and brown chalcedony are characteristic. The values in this ore are said to be in silver and copper.

In the Cuprite district chalcopyrite with less pyrite, galena, calcite, and quartz appear to have been deposited as sporadic masses in the limestone, as seams along joints, and as lens-shaped bodies along shear zones. Later these ores were altered by descending waters to chalcocite, carbonates, and oxides, the carbonates and oxides in large part replacing limestone. Faulting often accompanied or preceded the change. Contemporaneously a heavily iron-stained chalcedony was deposited in intimate association with the oxidized ores. Later, in some instances, drusy quartz was deposited upon the copper carbonates. The development is altogether too slight to determine what part of the secondary copper ores has been concentrated from sulphides originally lying in limestone now removed by erosion. It is probable, however, that a considerable proportion is of such origin and that when the oxidized ores are worked out the copper content will decrease. It may well be, however, that in this portion of the desert region the water level is very deep.

In the rhyolite north of the east end of the copper belt are some prospects. The values reported from these are gold and these deposits are undoubtedly to be more nearly correlated with the Tertiary mineralization of the Bullfrog and certain of the Goldfield ore deposits.

Water for the district at present is hauled from the Stonewall Springs, 17 miles distant. Available wood, except the almost valueless yucca, is equally distant. However, the Cuprite mines are only 18 to 25 miles from the railroad at Goldfield, and ore may be shipped from the district at a comparatively low cost.

Lida.—Lida is situated on the western border of the area surveyed, about 34 miles south of its northwest corner. A daily stage runs from Lida to the railroad at Goldfield. The Lida mining district was organized August 28, 1871, and in the succeeding decade some rich surface pockets of horn silver and silver-bearing galena were removed. The ore, probably picked, ran from $500 to $1,000 per ton. In the latter part of 1904 and the early part of 1905, the attention of mining men having been turned to southwestern Nevada, old mines were reopened and new locations made. Unfortunately, at the time of the writer's visit in December, 1905, the principal prospects were closed through litigation and in many cases pumps and ladders had been removed.

The country rock in the vicinity of Lida consists of dark-gray limestones and olive-green shales of Cambrian age. These sediments are in the main gently folded, although locally considerably disturbed. Small faults also occur. The limestone and shales are widely and in many places most intensely injected by a granite-porphyry which may perhaps be correlated with the post-Jurassic granite intrusions. Dikes of diorite-porphyry also cut the sedimentary rocks. So far as a hasty examination showed, these masses of igneous rock are not closely connected structurally with the ore deposits. The prospects are situated partly outside the area surveyed and partly on Mount Macgruder, to the south and southeast of the village. The latter prospects alone were examined and in most cases only the dumps were accessible.

The Florida-Goldfield Mining Company's shaft is situated near the mouth of a gulch which joins the Lida Valley about one-half mile below the village. When visited, the shaft, 150 feet deep, was filled with water to within 80 feet of the surface. The ore on the dump included Cambrian limestone rather heavily impregnated with iron pyrites, pyrite inclosed in veins of coarsely crystalline white calcite, and the same ore in white quartz veinlets. In some specimens galena and light-brown zinc blende were associated with the quartz veinlets carrying pyrite. Another and apparently still more uncommon sulphide, chalcopyrite, is sometimes superficially altered to malachite and azurite. The limestone cut by the quartz veins has been more or less silicified. An old open cut above this shaft shows a zone of brecciated limestone 4 feet in width healed by innumerable connecting quartz veinlets in which the above ores occur.

On the dump of the Thanksgiving mine quartz masses and veinlets cutting similar limestone were examined. In the quartz is much pyrite and less chalcopyrite.

The Lida deposits are partially fissure fillings and partially impregnations of the country rock. The oxidized ores appear to be largely replacements of the limestone. The oxidized zone is, for a desert country, very shallow.

In the early days of mining in the district considerable bunches of oxidized ore were hauled to Austin and Belmont. It is scarcely probable that all of these pockets have been found, and, with the improved transportation facilities, such deposits should pay well. Some of the ore mined from the newly located prospects is reported to run from $100 to

$500 per ton in gold and silver values. Such assay returns, however, in at least the majority of cases, were obtained from picked samples and are of no value in estimating the economic importance of a prospect.

The water level, to judge from the development work so far carried on in the Lida district, is comparatively near the surface. Much of the ore which has already been taken out is refractory and would require milling and smelting. While in comparison with the surrounding districts the Lida district is, in these respects, at a disadvantage, there is a fair growth of piñon and juniper on the hills surrounding the mines which will furnish, for a time at least, satisfactory fuel and some mining timber. Water sufficient for mining and domestic purposes flows from springs in and above the village and can be obtained in the Lida Valley at slight depths.

Lime Point.—The name Lime Point is applied to a ridge running northwest from Slate Ridge. Recently a number of claims have been located on it and some development work is now being done. The ridge is formed of a coarse biotite granite and Cambrian sedimentary rocks. The intrusion of the granite has strongly metamorphosed the limestone and the shales have become semischists. The granite itself is cut by diorite-porphyry dikes and by pegmatite and aplitic dikes. Later flows of basaltic rocks occupy small areas.

The Bullfrog-George mine is situated on the side of a rounded, boss-like, granite hill, near the Lida-Old Camp road. The surrounding hills are cut by quartz veins which weather in relief and can be traced long distances. Some of these contain feldspar and others can be traced into pegmatite dikes. The Bullfrog-George development work is being done on a quartz vein from 4 to 9 feet wide which is traceable about a quarter of a mile. The vein is vertical and strikes N. 70° W.

The vein at some places passes gradually into the granite, the white, translucent quartz of the granite grading into that of the vein without break. Again, the granite appears to have been shattered prior to the deposition of the quartz, which now fills linked cavities in the granite. The quartz vein sometimes sends branches into the granite. Apparently isolated in the quartz are small areas of pyrite and chalcopyrite, with less galena and chalcocite or a related sulphide. The quartz in many portions is intensely crushed, this crushing perhaps being contemporaneous with the faults which cut the diorite-porphyry dikes. The crushed fragments have been recemented by limonite or a chalcedonic quartz much stained by limonite. With these knife-edges of limonite and in limonite-stained cavities malachite, cerussite, and traces of azurite occur. Such quartz pans free gold, and coarse pannings were examined from the intensely iron-stained contact of the granite and quartz. The feldspars of the granite within 4 feet of the vein are often much kaolinized. At the east end of the quartz veins less shattering was noted. Vugs lined with quartz crystals are common. Other vugs are lined with cubes of purple fluorite one-fourth inch in diameter, while finely divided flakes of molybdenite are sporadically present in the quartz.

The quartz vein itself appears to be of pegmatitic origin and to have been deposited while portions of the granite were still viscous and other portions were comparatively solid. Later faulting occurred and the quartz vein was crushed. Since then limonite and chalcedonic quartz have recemented the quartz fragments. The period at which the sulphide mineralization occurred is unknown. The molybdenite and fluorite are probably of pegmatitic origin, while the sulphides were very likely formed later.

Water is at present hauled from a pipe line on the Lida-Old Camp road 9 miles distant, while the nearest fuel is found in the vicinity of Old Camp. The camp is 30 miles from the railroad terminus at Goldfield.

Tokop.—Tokop, in an air line, is 4 miles northeast of Old Camp and 25 miles by road west of south of Goldfield. Rugged hills and rounded domes rise from the much-dissected mesa lying to the east and northeast of the settlement. The rocks present are those already mentioned as occurring at Lime Point, with the addition of dikes of granite-porphyry which, to the north of the village, cut the Cambrian and are probably to be correlated with similar dikes observed at Lida. Rhyolite flows also form a considerable proportion of the mesa already mentioned. The Cambrian shales and limestones have been profoundly metamorphosed and near the granite are schists and garnet-quartz-epidote rocks. They are complexly folded and at places faulted. The granite is pink and coarse grained. From the presence of granite dikes in the sedimentaries and from certain mining data it is assumed that the contact of the granite and limestones has a very gentle dip and that deep mines in limestone near the contact will probably encounter granite.

The properties of the Gold Crest Mining Company, situated three-fourths of a mile south of Tokop, were examined in some detail. On the Ouida claim a vertical vein cuts the garnet-quartz-epidote rock, which strikes N. 10° E. and dips 20° W. This vein is 1½ feet wide and strikes N. 80° W. The quartz is white and semitransparent. The quartz of the vein has been intensely crushed and the fragments have been cemented by hematite and limonite. Dendrites of manganese oxide also occur. Some portions of the quartz are compact, with here and there an iron-pyrite cube unaltered, while other portions have a few vugs lined with quartz crystals or are honeycombed with iron-pyrite casts. From the fact that the compact varieties are refractory and the honeycombed varieties are free milling, it is evident that the gold was set free by the alteration of the pyrite. A mashed, greasy phase of the garnet-quartz-epidote rock on one side of the vein is said to pan gold, but whether the altered pyrite originally occurred in the altered limestone or whether the values were derived from the surface alteration of the quartz veins is unknown.

Angular fragments of altered limestone and shale are common near the borders of some veins. In such instances silicification has extended into the limestone and these belts, like the quartz veins, weather in relief. Such veins grade into sheared and brecciated zones of silicified limestone and these again are reported to carry values.

Another vein is similar to that first described, but the shattered quartz is cemented by a gray chalcedonic quartz, while still another at first sight appears crustified, but close inspection shows that the appearance is due to a longitudinal fracturing of the vein and subsequent filling by limonite and the chalcedonic quartz. Both forms of quartz are said to assay, but the earlier quartz appears to carry both the sulphides already mentioned and slight amounts of galena as noted in other veins. The chalcedonic quartz may appear to carry values, because sufficient care has not been taken to eliminate the older quartz from samples.

As secondary minerals, limonite, hematite, cerussite, free gold, and a little malachite were observed. Probably some chalcopyrite exists at greater depths. One of the last changes which these ore deposits have undergone is the deposition locally of a thin film of bluish-white chalcedony.

Mr. Joseph Mackedon, the manager, states that in several prospect holes the quartz veins have passed from altered limestone to granite without diminution in size or value of content. From the striking resemblance of these veins to those of Old Camp this is to be expected.

Waters carrying silica and metallic salts in solution appear to have deposited these substances in strong fractures which extend, in some cases at least, into the granite. The country rock was to a less extent impregnated. The quartz veins were subsequently crushed and iron oxides and chalcedonic silica were deposited in the fractures. Simultaneously, probably, iron pyrite was dissolved and the gold set free.

Water and wood for mining and domestic purposes are near at hand, and the distance to the railroad at Goldfield is 25 miles.

The Rattlesnake mine, near the properties described, appears to be in the same rock formation, and its ore deposits and those of Tokop are said to be similar. Eight or ten years ago the Rattlesnake produced $150,000, and it has recently been reopened. The veins of Tokop, like those of Old Camp, seem strong, and will probably be permanent to such depths as mining is possible. With depth, however, the ore will become refractory and may become leaner.

Old Camp.—Old Camp, near Gold Mountain, is situated 30 miles west of south of Goldfield and 20 miles southeast of Lida. The almost deserted village is situated near the center of the Gold Mountain mining district, organized January 25, 1868. Mines have been worked in the district intermittently since that time and several mills have been built, none of which are now in operation. Old residents estimate the total product of the district, including Old Camp, Tokop, and Lime Point, as $500,000.

Biotite-granite, probably of post-Jurassic age, is the predominant rock in the vicinity of Old Camp. It has many facies, the prevailing type being coarse grained and pink. Areas of altered Cambrian limestones and schists are less common than in the vicinity of Tokop and Lime Point. Rhyolitic and basaltic flows of Tertiary age cap some of the neighboring hills, and such buttes are in strong contrast to the rugged granite hills.

Abandoned mines and prospects are numerous in the vicinity and a number of prospects are being developed 2 or 3 miles south of the old town. The Central mine, which supplied the ore used in the mill at Old Camp, may be taken as a type of the ore deposits in the granite of this region. This mine is situated on the side of a deep gulch 1½ miles north of east of the town. Five tunnels with an average length of 300 feet pierce the granite, and all are situated on a single vein or system of connecting veins.

The feldspar of the granite within 20 feet of the quartz zone is considerably kaolinized and the biotite is bleached or altered to a sericitic mineral. The quartz vein, or rather the zone within which the innumerable connecting quartz veinlets and stringers occur, is from 1½ to 6 feet wide. The proportional amount of quartz increases with the narrowing of the zone. The ordinary veinlets are from 2 to 5 inches wide. The silicified zone also contains many ellipsoidal and globular areas of quartz which, at least in the plane of observation, are independent masses.

The quartz zone in places changes its direction 90° within 100 feet. While minor post-mineral faults are common and fault the zone from 6 inches to 7 feet, the major changes in strike and dip are evidently original structures. The form of this zone is probably due to original lines of weakness similar to those to which the pitches and flats of the southwestern Wisconsin lead and zinc mines owe their origin.

The quartz is white and translucent or slightly smoky, with a strong vitreous luster. It contains occasional vugs with crystals up to an inch in length. In places the clear quartz seems to grade into a gray chalcedonic form, the deposition of which by water can scarcely be doubted. Isolated crystals of pyrite, with very rare crystals of chalcopyrite and galena, are embedded in the quartz. The former abundance of the pyrite in particular is shown by numerous iron-stained cavities of cubical form. Both hematite and limonite occur, and where these are abundant the gold values rise. An occasional malachite stain and a cerussite coating are present. Manganese-dioxide dendrites occur in the granite and are probably derived from the alteration of the granite rather than from a decomposing vein mineral. Horn silver is reported to be present in small amounts, but was not seen. The ore is free-milling, the arrastres, now abandoned, having saved about 75 per cent of the assay value.

Films of a bluish-white chalcedony were noted at a number of places. Some chalcedony was deposited prior to the oxidation of the pyrite, while some was deposited after partial or complete oxidation.

While the quartz is rather similar to quartz of pegmatitic origin in the district and the form of the ore deposited rather suggests that of a pegmatitic dike, the apparent gradation into chalcedony is strongly against such a view. Water appears to have filled a most complex zone of fracture with quartz and sulphides, the gold probably originally being contained in pyrite. Later oxidizing waters attacked the sulphides and altered them to oxides and carbonates, setting the gold free. These waters apparently carried some silica in solution, which was deposited as chalcedony.

The mines in the vicinity of Old Camp are situated near water sufficient for mining and milling purposes. Wood for fuel and mining timber is standing within 2 or 3 miles. The railroad terminus at Goldfield is 35 miles distant.

Oriental Wash.—Several prospects, now abandoned, are located 16 miles south of Lida, on the western border of the area surveyed. The hills in which these prospects occur are a continuation of the Gold Mountain ridge and lie south of the Oriental Wash and east of Death Valley. Here a mass of post-Jurassic biotite-granite injects a highly altered series of limestone of Cambrian or possibly of Silurian age. Contact metamorphism has developed brown garnet, epidote, quartz, and other metamorphic minerals. The granite contains numerous pyrite crystals, probably original. Rhyolitic and basaltic rocks, remnants of eroded Tertiary lava flows, also occur in the vicinity.

At one prospect a thin quartz vein cuts the limestone. Malachite, azurite, and chrysocolla, and limonite-stained chalcedonic quartz occur in irregular patches and veinlets through the quartz. Vugs occur in the secondary minerals and the azurite and malachite are often set with numerous quartz crystals. A little chalcopyrite is embedded in the oldest quartz, and cores of chalcopyrite are surrounded by the other copper minerals. A vein of malachite 1 inch in width is exposed in another prospect, apparently replacing the limestone.

The general resemblance in structural relations and mineralogic composition of these deposits to those near the granite of Oak Springs is worthy of note. The nearest water to these prospects is Sand Springs, 6 miles away. Fuel could be obtained from Gold Mountain, within 10 miles. By road the prospects are 45 miles from the railroad terminus at Goldfield.

NYE COUNTY, NEV.

Silverbow.—The village of Silverbow is situated in the canyon of Breens Creek, on the west side of the Kawich Range and about 42 miles north of east of Goldfield. The principal prospects are within 3 miles to the east, northeast, and northwest of Silverbow. The first locations were made in November, 1904. When visited by the writer (July 20, 1905), Silverbow was the supply center for several hundred men and a number of shallow prospect holes had been sunk.

The north end of the rugged Kawich Range is, with unimportant exceptions, composed of rhyolites and other siliceous eruptive rocks. The ore deposits lie in rhyolite, which in the vicinity of veins is either kaolinized to a soft chalky mass or silicified, the latter alteration being perhaps more common. The silicified rhyolite is sometimes flinty in texture and is very resistant to erosion, and in consequence forms prominent minor ridges parallel to the veins. In the kaolinized facies the feldspar phenocrysts are either kaolinized or removed in solution, while biotite, if present, is altered to a silvery micaceous mineral. Either facies may be intensely stained red, brown, or yellow by iron salts.

The more important prospects are located in parallel quartz veins or lenses which widen, thin, and often play out, forming mineralized bands whose strike in the district is in many cases north of west. The individual quartz veins vary in width from a fraction of an inch to 5 feet, and these are often connected by minor cross veins. While in many cases the quartz was deposited along pre-mineral faults, in others it occurs along joints, which sometimes form intersecting systems. Quartz likewise often fills the spaces caused by brecciation and forms in solution cavities in the rhyolite. The quartz is, as a rule, white and translucent or colorless and transparent, although in the Blazier tunnel a single vein of amethyst was noted. Crystal-lined vugs are common. Crustification is often beautifully developed, fortification-agate and mammillary forms being common.

The quartz is more or less stained by iron salts, rarely by malachite. In the quartz specks of stephanite, ruby silver, silver chloride, and probably other silver ores occur. Of these, silver chloride is certainly a secondary mineral, and to a limited extent is disseminated in the country rock. Gold occurs free. Silver is the predominant metal, and $1 in gold to $3 in silver is perhaps an average for the whole camp, although in some prospects the silver values are twenty times those of gold. The ore runs from $6 to $250 per ton, while higher values are reported. Since the writer's visit strikes in which gold predominates over silver have been reported.

In other prospects values occur in limonite stringers in the country rock, while in several prospects a greasy, crushed rhyolite carries gold values.

The striking similarity between the ore deposits of Silverbow and certain of those of Goldfield is worthy of note. Ascending water, carrying silica and metallic salts in solution, appears to have deposited its burden largely in preexisting cavities. Simultaneously waters wandering from the main channels silicified contiguous portions of the rhyolite. The kaolinization is presumably a later feature. Movement has since occurred in the veins, and they have been more or less faulted and brecciated. Surface waters have altered silver sulphides, pyrite, and probably less amounts of chalcopyrite to the corresponding chlorides, oxides, and carbonates, while secondary sulphides have also been formed. Gold, probably originally in pyrite, was simultaneously set free.

Timber and water are abundant near the mines. Goldfield is about 50 miles distant by road.

Blakes Camp.—Blakes Camp is located on one of a number of rhyolite inliers which protrude from the "wash" 12 miles northwest of Silverbow. The prospect was discovered near the end of June, 1905. A fault with well-defined walls coursing N. 80° E. cuts the rhyolite. Along this fault a zone from 18 to 24 inches wide is crushed to a fine clay in which are embedded slickensided fragments. The ground-up rhyolite is white or stained by hematite or limonite and to a less extent by manganese dioxide. This material is said to pan free gold. The rhyolite surrounding the fault is more or less silicified.

Eden.—The mining camp of Eden is situated near the mouth of Little Mill Creek Canyon, on the east side of the Kawich Range. The first locations were made February 20, 1905, by Mr. John Adams.

Three distinct vertical zones of mineralization cross Little Mill Creek from north-northeast to south-southwest, respectively one-fourth, one-half, and five-eighths mile above the old mill. The country rock is rhyolite, which in many places is intensely silicified parallel to the mineralized zones. In some cases the only indication that the material is not vein quartz is the presence of phenocrysts of slightly smoky quartz. Thin sections show fine quartz mosaics replacing both groundmass and feldspar phenocrysts. While the contact between the silicified and the unsilicified rhyolite is as a rule rather sharp, in some places there is transition. The quartz and silicified rhyolite stand out in distinct walls, aptly called by the miners "dikes," which follow the mineralized zones.

The central zone has been more developed than the others and was studied in more detail. This zone is situated along a line of faulting and brecciation, and the rhyolite near the zone is mashed. The mineralized zone varies from a vein of quartz 3 feet wide, with occasional rhyolite horses, to a band of silicified rhyolite 8 feet wide, intensely netted by quartz stringers. Parallel quartz veins more or less continuous and connected by cross veins are transitional between the two forms along the strike. The quartz, often crustified, is white and more or less iron stained. Finely divided sulphides impart a blue tinge to some of the quartz, and the parallel position in thin bands of the white and blue quartz shows clearly their contemporaneous origin. The normal crystalline quartz grades into a compact, white, flinty variety, which is said to be a good carrier of gold. Vugs usually elongated parallel to the walls of the veins are characteristic. Colorless quartz crystals are common in these vugs, while botryoidal quartz walls are less common. The vein in some portions is composed of clusters of quartz plates an inch in length set at right angles to the vein walls. This central zone is a silver bearer, the gold values being one-tenth those of silver. As silver ores, ruby and native silver are reported, intimately associated. Secondary silver chloride in knobs and wire-like masses is widely distributed in the vugs, and the silicified rhyolite itself carries values. Iron sulphide was noted in a few small specks in vein quartz.

The upper zone of mineralization is said to be very similar to the middle zone. The lower zone also is somewhat similar to the middle zone, although there is perhaps less parallelism and constancy of the quartz veins. The strike is more northerly. Pyrite locally impregnates the rhyolite. The flinty quartz already mentioned is abundant in this ledge, and the values are largely gold. The resemblance of the Eden deposits to those at Silverbow is striking, and the genesis was doubtless similar.

Water and fuel are abundant. Tonopah, the supply depot, is 70 miles distant.

Kawich.—Kawich is situated in a detrital embayment on the east side of the Kawich Range. The town is 54 miles south of east of Goldfield. The district is known as the Goldreed mining district. The first locations were made in December, 1904, and early in the spring of 1905 several hundred men rushed to the camp. When visited by the writer (August, 1905) there were about ten miners at work. Considerable development work has been done, two shafts reaching 150 feet, and several thousand feet of drifts have been driven.

The mines are situated on a gently sloping area of wash, from which numerous small, rugged outcrops of monzonite-porphyry and smooth ones of rhyolite protrude. The monzonite-porphyry is older than the rhyolite and has so far been the ore bearer. Fresh specimens of the former are gray in color, with many rather large phenocrysts of feldspar and either hornblende or biotite, or both.

The first locations were made on the property of the Goldreed Mining Company. Here a rugged outcrop of intensely silicified monzonite-porphyry, dark brown on weathered surfaces, contains in many cavities plates of hackly gold, some of which are an inch in diameter. Numerous other areas of silicified monzonite-porphyry have been located by prospectors, but at none was gold visible to the eye, although many panned gold. The silicified porphyry is light grayish brown on fresh surfaces and breaks with a conchoidal fracture. The boundary between the silicified and unsilicified portion is usually sharp. The numerous cavities are due to the removal of the monzonite-porphyry phenocrysts prior to the deposition of native gold. Strong iron stains and some dendrites of manganese dioxide are associated with the gold. The iron stains probably point to pyrite as the original source of the ore, an inference strengthened by the presence of gypsum. Quartz veinlets cut the silicified monzonite-porphyry but are said to carry no values. Certain clear phenocryst-like quartz areas indicate that silicification continued after the removal of the phenocrysts usual in the porphyry. The deepest shafts show that the silicified porphyry holds its width, although up to the time of this examination the values are low except at the surface. At the Goldreed mine good values have been obtained in a kaolinitic substance found in the cavities of the silicified monzonite-porphyry at the 100-foot level. Associated with the silicified facies are white kaolinized facies, which are often stained red or purplish by iron salts.

Iron pyrite has been encountered on the 150-foot level at the Goldreed mine disseminated in unsilicified monzonite-porphyry. Its assay value is low. Several thin veins of pyrite occur on the lower levels of the Diamond No. 2. These veins are crustified, and vugs sometimes occur in the center. This pyrite is said to assay $35 in gold per ton.

The silicified porphyry has been considerably faulted and slickensides and breccias are common. At the Goldreed mine the faulting has been very complex and certain cavities appear to be due to faulting. These cavities are wedge-shaped and reach a maximum length of 5 feet. At the Chief Kawich the faults strike N. 50° W., parallel to the silicified monzonite-porphyry boundary, and dip 80° SW. At the Diamond No. 2 the faults dip 45° E. The step-like offsets in the silicified monzonite-porphyry on which the Chief Kawich and the Goldreed mines are situated is rather suggestive of faulting, although the effect may be due to a chance distribution of several small areas of silicified porphyry.

The resemblance between the Kawich and Gold Crater deposits is close. It is probable that waters bearing silica in solution rose along joint and fault planes and that silica more or less completely replaced the rock contiguous to the fractures. Pyrite was probably deposited simultaneously, partly in the country rock and partly in open fissures. Since the silicification the veins have been faulted. The kaolinization of certain portions of the porphyry was probably contemporaneous with the surface alteration of the original sulphides. From the lean character of the pyrite so far encountered it is probable that the rich surface gold deposits have been concentrated from the pyrite contained in many feet of monzonite-porphyry, which have been removed by erosion. Other rich bodies of ore will, however, probably be encountered above the level of ground water, which is here deep.

Water is obtained at Cliff Spring, 12 miles east of the settlement, and piñon grows on the Kawich Range, 8 miles north of it. Tonopah is 70 miles distant by road.

Hills in the vicinity of Cactus Spring.—Cactus Spring is located in a group of hills lying 24 miles east of Goldfield. Rhyolite, the chief rock formation of these hills, is kaolinized or silicified in several areas near the spring. Quartz veins with many vugs cut the altered rhyolite, the quartz being coarsely crystalline and white in color. Surface outcrops are much iron stained. Pyrite and chalcopyrite are sparingly present in the quartz and somewhat impregnate the surrounding rhyolite. Both fissure filling and impregnation of the country rock have occurred. Free gold is reported from several prospects.

Wellington.—Wellington is situated in low hills 11 miles south of Cactus Spring. Claims were first located in August, 1904. When visited (July, 1905), several men were doing development work.

The country rock, a white rhyolite, is considerably altered in the vicinity of the veins, the ground mass being chalky, the biotite altered to a silvery-white hydromica, and the feldspar kaolinized. It is deeply stained by limonite. The rhyolite is apparently cut by dikes of an altered andesite or latite of purple color.

Both rocks along a zone striking N. 70° E. are cut by quartz veins, many of which strike parallel to the extension of the zone and dip northward. The larger veins are from 2 to 4 feet in width. Connecting the larger veins are numerous quartz stringers, which course in all directions, often cementing crushed areas. The semitransparent and crystalline quartz is white, although locally intensely stained by limonite. Vugs with small quartz crystals are very common, as is crustification. Minor veins of calcite were observed. Differential movement has occurred parallel to some of the veins, and the quartz is often intensely brecciated, while minor faulting across the strike was noted in several places.

The values reported are largely gold, silver constituting but one-thirtieth of the assay value. The ore is free milling and the gold is closely connected with the limonite.

The quartz and the contained ores were deposited in joints, in the interstices of breccias, and along small and possibly large fault fissures. The veins have been faulted and the quartz crushed. Only ores oxidized by surface waters have as yet been encountered.

The railroad at Goldfield is approximately 28 miles from Wellington. Water and wood are obtained from Antelope Spring, 12 miles distant.

Trappmans Camp.—Trappmans Camp is situated 34 miles south of east of Goldfield, in low, rounded hills of granite, which is cut by pegmatite, aplite, and rhyolite dikes. Inclusions of biotite and muscovite schist are common in the granite. The veins were discovered by Messrs. Hermann Trappman and John Gabbard in June, 1904. At the time of the writer's visit, a year later, the Trappman Mining Company, of Goldfield, Nev., had five men employed in opening up the property, the chief development in July, 1905, being a shaft 50 feet deep.

The prospects are in granite, and three distinct periods of quartz formation were noted—first, quartz lenses probably of pegmatitic origin; second, quartz veins of distinctly later formation, which in one place are said to cut the rhyolite; third, quartz veins of a third generation, which cut the second. The latter class of veins is often well crustified.

The pegmatitic quartz forms bodies varying from minute stringers in the granite to lenses one-fourth of a mile long and 40 feet wide. On the contact single quartz individuals seem common to both granite and the quartz lenses. The quartz is hard and whitish, and in some places intensely brecciated and stained by limonite. It is said to carry silver and gold values.

The second class of quartz veins has sharp contacts with the granite. These veins are exceedingly common in the vicinity of Trappmans Camp, and vary widely in strike and dip. In limited areas they tend to form series of veins, often along parallel joint planes in the granite. In width the veins vary from an inch or less to a foot or more and the parallel series are sometimes a number of feet thick. These veins are sometimes faulted, as indicated by the presence of breccias, while the surrounding granite shows considerable differential movement. The quartz is slightly bluish, but is usually stained red or brown by hematite and limonite. Vugs elongated parallel to the direction of the veins are sometimes seen. On encountering the first veins, in the one instance noted, these veins are deflected downward.

The veins of the third class are of later origin than those of the second, and cut them. As a rule they are more narrow and less continuous and dip more steeply than the veins of the second class. The veins of this group often curve sharply, and the quartz in them is similar to that in the second group.

In the vicinity of the vein the granite is cut by joints stained by limonite and manganese dioxide, which are parallel to or join the quartz veins at low angles, and the surrounding partially decomposed granite is said to carry values. The granite near the veins is sometimes thickly peppered with cubes of pyrite altered to limonite.

The ore of the two younger sets of veins so far encountered is practically all oxidized, although a little original galena remains. The predominant original sulphide was pyrite, and limonite cubes after pyrite are common in the quartz. Assays show the values to be in the proportion of 1 of gold to 4 of silver. Some silver chloride was noted, while secondary native silver is reported. In one prospect calcite was noted as a gangue, with quartz.

While the quartz of one set of veins is of pegmatitic origin, its mineralization is probably later and genetically connected with the filling of the fissures of the second or possibly the third system. After the veins of the second system were fractured a second period of mineralization followed, perhaps in Tertiary time. Later the veins were crushed and surface waters have more or less completely oxidized the sulphides.

Wood and water are hauled from Antelope Springs, some 9 miles away. Trappmans Camp is 40 miles by road from Goldfield.

Wilsons Camp.—Wilsons Camp, situated on the north slope of O'Donnell Mountain, is 2 miles north of Trappmans Camp, and was discovered in May, 1904. Five miners were employed in July, 1905. At that time several shallow shafts and short tunnels were open.

The predominant country rocks are a white altered rhyolite and a biotite-andesite. Both rocks are cut by rather steeply dipping quartz veins, the majority of which strike northeast, although some strike east. The quartz veins, often crustified, are characterized by quartz-lined vugs. Since its formation the quartz has, in instances, been crushed. Limonite and less commonly malachite stains were observed on the quartz.

The reported assay values run from $110 to $180 per ton, and the average proportion is 1 of gold to 5 or 6 of silver. These quartz veins are to be correlated with the veins of Silver Bow.

The economic conditions at Wilsons Camp are similar to those at Trappmans.

Gold Crater.—The mining camp of Gold Crater is situated 10 miles east of the summit of Stonewall Mountains. Gold Crater is an inlier of older rocks, which protude in rounded hills above the basalt flow of the Ralston Mesa. These older rocks are much altered, but appear to be predominantly flows of andesite with, perhaps, more acid varieties. The first locations were made in May, 1904. In the fall of 1904 several hundred people rushed to the camp, but few remained long. At the time of visit (July 7, 1905), a number of lessees were at work.

The rocks have been in some cases strongly silicified, in others changed to a chalky mass through kaolinization. In the silicified facies the feldspar phenocrysts have often been entirely removed, while the biotite has been altered to a silvery micaceous mineral. The silicified eruptives weather into rugged crags and wall-like exposures. The country rock has been fractured, often brecciated, and in instances faulted. It is often intensely stained by limonite and hematite, especially along fractures, and from such places rich gold pannings are obtained. The ore is said to run from $40 to $240 per ton. A little chrysocolla was observed along some joints.

Waters carrying silica and metallic salts in solution appear to have ascended along faults, brecciated zones, and joints in the country rock, and there to have deposited silica, pyrite, and some copper sulphide. Later surface waters oxidized the sulphides and set the gold free. The original deposition was without much doubt an impregnation of the country rock, as is the case with the secondary minerals. There is a notable resemblance between these deposits and those of Kawich and certain of those of Goldfield.

Gold Crater is dependent for its water supply on tanks located on the basalt mesa and on two wells, respectively, 3 and 9 miles distant. Fuel for mining purposes is obtainable from the Stonewall Mountains. Goldfield is 27 miles distant.

Stonewall Mountains.—The Stonewall Mountains lie 17 miles southeast of Goldfield and are of notably symmetrical form. The predominant formation of the mountains is a rhyolite flow, which is cut by monzonite-porphyry. Quartz veins and stringers are very abundant, particularly on the north border near Stonewall Spring. These quartz veins and stringers fill faults, joints, and the cavities of brecciation, in both formations.

The most prominent vein follows a fault scarp immediately south of Stonewall Spring. The fault strikes S. 65° W. and dips 70° NW. The quartz vein is in some places simple and 40 feet wide, while in others it is complex and composed of many parallel veins. Brecciation often accompanies the faulting, the interstices between fragments of the country rock being filled with quartz. The quartz is white or colorless, rarely greenish yellow, and is beautifully crustified. Vugs with quartz crystals or mammillary quartz are common. The quartz has locally been fractured and slightly displaced, and a second quartz has filled the cavities. Heavy limonite and slight azurite stains were noted in the quartz, while pyrite is locally developed. Prospectors report traces of gold at a number of places. Timber and water are at hand in abundance.

Oak Spring.—Oak Spring is situated 50 miles northeast of Bullfrog. Here massive rounded hills of Carboniferous limestone and sandstone are injected by irregular masses of biotite-granite. The limestone near the contact is steeply tilted and has been altered to a white marble containing brown garnet, epidote, tremolite, and other metamorphic minerals. The contact facies of the granite contain rather abundant crystals of pyrite, probably of pyrogenic origin. Tertiary lavas and sediments form mesas which surround the older rocks.

In granite 1½ miles nearly due south of Oak Spring, quartz veins striking N. 30° E. and dipping 15° NW. and from 6 inches to 3 feet wide have been staked. The quartz is white and slightly sugary. Some is intensely brecciated, the cracks being stained by hematite and limonite. Vugs with small quartz crystals occur. Sulphides, sparingly present, are pyrite, chalcopyrite, galena, and zinc blende, named in the order of their abundance. From these the following secondary minerals are derived: Hematite, limonite, malachite, azurite, and cerussite. A coating of a greasy mineral in silvery tablets frosts some of the cavities. The values in this ore are said to be gold, with less silver. These deposits are similar to the second and third vein systems at Trappmans Camp.

The pegmatitic-quartz veins, abundant in a small granite mass three-fourths of a mile east of south of the spring, contain pyrite crystals, as do the less acid pegmatites and the surrrounding and genetically related granite. This quartz is said to carry good gold and silver values, presumably in the pyrite.

Three hundred yards southwest of Oak Spring and down the same ridge is a 25-foot shaft in Carboniferous limestone, here locally horizontal. A vein 2 feet wide which strikes N. 35° E. and dips 70° NW., cuts the limestone. The vein is formed of malachite, chrysocolla, and a jaspery quartz which is deeply stained by blotches of manganese dioxide and limonite. Striking vugs in malachite, lined with later azurite which in turn is covered with clear quartz crystals, resemble copper-sulphate crystals. Massive yellowish-gray cerussite (lead carbonate) is also present. Post-mineral faulting has occurred. The secondary minerals, which alone are seen, partially replace the limestone and partially fill preexisting cavities.

The so-called turquoise mine at Oak Spring is a small cut in the metamorphic Carboniferous limestone 1½ miles south of the spring and three-fourths of a mile from the granite contact. Two veins strike north and south and dip 65° W., apparently parallel to the bedding of the limestone, which is here partially marmorized and silicified. The wider vein varies in width from 2 inches to 1 foot and can be traced several hundred feet. Four feet away is a parallel vein, the two being connected by a few chrysocolla stringers. The vein is composed of a mottled mosaic of chrysocolla and a dark, compact, jaspery quartz, stained in some cases by limonite and in others by manganese dioxide. The chrysocolla is usually verdigris green, although picked pieces are a beautiful robin's egg blue. The substance is usually opaque, but some is slightly translucent. The chrysocolla is commonly massive, sometimes with a botryoidal structure, and in some massive phases an occasional cleavage face is seen.

The chrysocolla is cut by managanese dioxide and white calcite or quartz veinlets. Chrysocolla veinlets of slightly different color cut one another, showing that the formation of this mineral extended over a considerable period. Associated with it is a crystalline, bottle-green, semitransparent mineral whose cleavage faces reach a length of one-half inch. A radial structure is sometimes observed. This mineral is embedded in the chrysocolla or cuts it in veins and is of contemporaneous age. It is probably brochantite, a hydrous sulphate of copper. Both the chrysocolla and brochantite, were determined by Dr. Waldemar T. Schaller. Post-mineral faults cut the veins and parallel them.

In these copper deposits the minerals exposed are all secondary. Malachite, chrysocolla, brochantite, cerussite, a jaspery quartz, and limonite seem practically contemporaneous. There is considerable evidence that the formation of the copper minerals and the jaspery quartz extended over a considerable period, during which some fracturing occurred, and in consequence the relations between these minerals are complex. They partly replace the limestone and partly fill fissures. Azurite, quartz, and calcite are of later origin.

The pieces of robin's egg blue chrysocolla closely resemble turquoise, and several hundred pounds of the mineral have been sold for this gem. The mineral takes an excellent polish. The largest piece of pure chrysocolla seen was 6 by 3 by 2 inches.

Oak Spring furnishes good water sufficient for domestic purposes and several other springs exist in the general vicinity. The Oak Spring butte is timbered to some extent. Caliente, on the San Pedro, Salt Lake and Los Angeles Railroad is the natural shipping point.

Bare Mountain.—Bare Mountain forms the east wall of the Amargosa desert, from Gold Center to a point 20 miles south. The rugged mountain ridge is intensely dissected by V-shaped canyons. The surrounding hills are composed of Tertiary rhyolitic and basaltic rocks, but the mountains themselves are formed of sedimentary rocks. Limestone is the predominant rock, probably of Ordovician age for the most part. The limestone is mostly black in color and of fine grain, although areas, particularly in the northern part, are white marble of medium grain. Interbedded with the limestones are light-colored quartzites and silvery muscovite-schists. At the north end of the range pegmatite dikes are rather common. A few intrusions of a dioritic rock are also found here. The limestone has been complexly folded and vertical dips are common. Faults frequently occur, reversed faults perhaps being more common than normal faults.

Quartz veins are common in the north end of the range and mineral locations were made on some of them early in 1905. An older set of veins, sometimes folded, is faulted by a younger set.

The Decillion claim is located in the northwestern portion of the range near the mouth of a deep canyon. The principal development work is a 50-foot shaft. Quartz veins and stringers reaching a maximum thickness of 1 foot cut limestone and schist. Some of the veins strike east and west and dip 45° S. Chalcopyrite in grains up to one-half inch in diameter is disseminated through the quartz. Malachite and a little azurite stain the quartz around the sulphide and have been deposited in cavities in the quartz. The quartz vein since its deposition has been faulted and crushed, the crushed fragments being in places cemented by granular gypsum, while gypsum crystals line some cavities. The ore of this mine is said to run high in silver, with low gold values.

The two 50-foot shafts of the Kismet Mining Company, better known as the Lonsway property, are situated on the crest of a high ridge 1½ miles southwest of Beatty. The country rock here, a quartzite, strikes N. 35° W. and dips 15° NE. The quartz vein, which is traceable several hundred feet, is from 1½ to 2 feet wide. It strikes N. 85° W. and dips 55° S.

The quartz is white or pinkish from iron stain and has a sparry texture. At the surface the quartz is deeply stained by limonite and hematite. This is said to have been locally charged with gold, probably derived from pyrite, which occurs with limonite in quartz at the bottom of the shaft. The quartzite near the vein is sheeted.

In other portions of the range galena cubes in quartz veins were noted.

The quartz and associated sulphides were deposited in open east-west fissures. Later the veins were faulted and crushed and surface waters have more or less completely altered the sulphides to oxides and carbonates, forming free milling ores.

The mines on Bare Mountain are controlled by practically the same economic conditions as are the mines of the Bullfrog mining district. Good water can be obtained in the springs of Amargosa River, one-half mile away. The most accessible wood is that of the Grapevine Range, 25 miles away. The mines are 1 to 3 miles from the proposed railroad to the Bullfrog district.

Happy Hooligan mine.—The Happy Hooligan mine is situated at the east base of the Grapevine Range, 9 miles northwest of Bullfrog. Here the major portion of the mountain range is formed of rhyolitic rocks in flows and, possibly, intrusive sheets. The rhyolite of the vicinity is pinkish or yellowish. Quartz and fewer biotite phenocrysts are still observable, while the feldspars are largely represented by numerous casts. In the vicinity of the Happy Hooligan mine are several small areas of much brecciated gray limestone, with minor quartzite beds of possibly Ordovician age. Ransome states that a tunnel driven since the writer's visit shows a thin sheet of basalt between the rhyolite and limestone. The test pits of the Happy Hooligan mine are located at the contact of this basalt flow and the limestone. At the contact the basalt is reddened by hematite and altered to a greasy substance which pans fine free gold, as does the limestone when decomposed. Gold values also occur at the contact of the basalt and the quartzite. This contact has been traced a number of hundred feet and values are reported from all test pits.

The ore is free milling and no sulphides were observed. It is said to run $40 in gold, the values appearing to be closely associated with limonite and hematite. Eventually the deposit will probably grade into a gold-bearing pyrite contact deposit.

Several springs are situated near the mine and fuel can be obtained within 6 miles. The road to Bullfrog is rather heavy.

INYO COUNTY, CAL.

Chloride Cliff.—Chloride Cliff is situated on the crest of the rugged Grapevine Range, 15 miles south of Bullfrog. The country rock is a series of early Paleozoic interbedded muscovite-schists, impure quartzites, and yellow and white limestones, all altered in varying degrees. Some lenses of a hornblende-feldspar gneiss, probably a metamorphosed igneous rock, appear to be intruded along the bedding planes of the series. These rocks are intensely folded in a complex manner and faults are common.

On the range crest, at Chloride Cliff, the limestone strikes N. 15° W. and dips 30° E. A steeply inclined fault, coursing N. 50° W., cuts the limestone. The limestone along the fault is silicified and in it are disseminated galena and some chalcopyrite. The secondary ore is a porous yellowish lead carbonate with some malachite stains. The surface outcroppings are much stained by limonite.

At another place a 4-foot vein of quartz lies between the gently dipping hornblende-gneiss and the schist and altered limestone above. The quartz is deeply iron stained and the crushed portions have been recemented by limonite. The writer traced the vein 200 feet, but it extends much farther. It is reported that one sampling across the vein gave values in gold averaging $1,500 per ton. The ore is free milling.

At a third prospect a reversed fault cuts the schist member of the series, which here strikes N. 60° W. and dips 15° NE. A quartz vein 2 to 3 feet wide occupies the fissure. The quartz is stained by limonite and the only original sulphide seen is pyrite. Small nodules of native copper are rarely associated with the limonite stains. The ore is said to assay from $13 to $500 per ton in free gold. The values are associated with limonite.

The prospects at Chloride Cliff are on either fissure veins or contact deposits. In some cases the quartz and accompanying sulphides probably filled open fissures, while in others the limestone was metasomatically replaced. There is a distinct tendency for galena to be the predominant sulphide in limestone and pyrite in the other country rocks. Since the deposition of the quartz the veins have been crushed and surface waters have produced from the original sulphides native gold, copper, cerussite, malachite, and limonite. The deposits are structurally those which hold their values well with depth, and if surface enrichment has not been out of all proportion to the original sulphide values further development is well justified.

Water is at present packed on burros from Keane Spring, 4 miles distant. Wood suitable for fuel occurs on the Grapevine Range 10 miles north of the prospects, but at present must be teamed by way of Bullfrog. A fair road connects the prospects with Bullfrog, the shipping and supply point.

Gold Belt.—Gold Belt, a deserted camp in the Panamint Range, is situated in a deep gulch near the southwest corner of the area surveyed. Here the black, fine-grained Silurian limestones are injected by a batholith of diorite, in which both hornblende and biotite are usually associated. The limestone has been altered near the contact to a white coarse-grained marble. A number of men are said to have rushed to this camp in the spring of 1905, but little work was accomplished. The more important development work was done on certain thin veins or lenses in the diorite. The ore contains a little chalcopyrite, probably a portion of the original sulphide unaltered. Of clearly later origin are chrysocolla, malachite, and a dark-brown or black iron-stained chalcedony of approximately contemporaneous age. These minerals are coated with small quartz crystals. This ore is said to pan free gold. Similar ore is reported from other localities in this diorite area. A specimen from near the headwaters of Cottonwood Creek is identical with the ore of Oak Spring already described, both chrysocolla and brochantite being present.

Water and fuel are near by. Gold Belt is 50 miles from Bullfrog by trail and road.

A RECONNAISSANCE OF THE MINERAL DEPOSITS OF NEW MEXICO.

By Waldemar Lindgren and L. C. Graton.

INTRODUCTION.

A general reconnaissance of the mineral deposits of New Mexico was undertaken during the field season of 1905. The two principal objects in view were, first, to obtain, for practical purposes, a needed summary of the condition of the mining industry throughout the Territory, and, second, to develop general conclusions bearing on the origin of the deposits. It was held that such a reconnaissance would bring out the salient facts relating to genesis better than a detailed examination of one or two of the larger districts. In addition, it was expected that the work would disclose much of interest and value regarding the general geology and serve as a basis for a preliminary geological map of the Territory.

Dr. C. H. Gordon, of Socorro, N. Mex., examined the deposits of Sierra, Socorro, and part of Luna counties. Many statements based on his work will be found in the following pages. Mr. F. C. Schrader, of the United States Geological Survey, examined a number of copper deposits in the northwestern part of the State.

A summary of the facts ascertained and some of the conclusions drawn from them are contained in this article, which is simply a preliminary statement, possibly to be modified by the more detailed study of collections and notes now in progress.

GENERAL GEOLOGY.

PHYSIOGRAPHIC PROVINCES.

New Mexico is divisible into four more or less distinct regions or provinces, the division being based on the character of the surface of the country.

The northwestern portion of the Territory is a diversified plateau region which, extending across northeastern Arizona and southwestern Colorado into Utah, forms part of the Great Interior Plateau of the western United States. This plateau has been considerably modified by recent erosion, but presents in broad view a fairly flat expanse of large extent.

To the south of the great plateau and separated from it by a somewhat indistinct boundary is the region of desert ranges. This province occupies nearly the whole of the southwestern quarter of New Mexico. It extends southward into Mexico and, sweeping diagonally across central Arizona, connects with the Basin Ranges of Utah and Nevada. This province is characterized by broad Quaternary desert plains, through which protrude isolated knobs, clusters of peaks, and comparatively short ranges. The latter extend in generally parallel north-south directions, but they can not be correlated into any system.

Bounding the great plateau and the desert-range province on the east the central mountain belt extends along the middle of New Mexico and is one of the most important physiographic features of the Territory. To the south it is represented by ranges along the Rio Grande in Texas and Mexico and to the north it merges into the Sangre de Cristo Range of Colorado, and thus constitutes the southerly extension of the Rocky Mountains. The main drainage line of the region, the Rio Grande, which traverses the entire Territory from north to south, lies along the west side of this mountain belt. From the Colorado line to a little south of Santa Fe this mountain province is conspicuous and distinct, comprising the lofty Mora, Taos, and Santa Fe groups or ranges. Farther south the province is represented by three chains of disconnected ranges which nevertheless conform in trend to the more prominent ranges to the north. On the east are the Jicarilla Mountains, the Sierra Blanca, and the Sacramento and Guadalupe Mountains. The central and best-defined chain is made up of the Sandia, Manzano, Oscura, San Andreas, Organ, and Franklin ranges, to

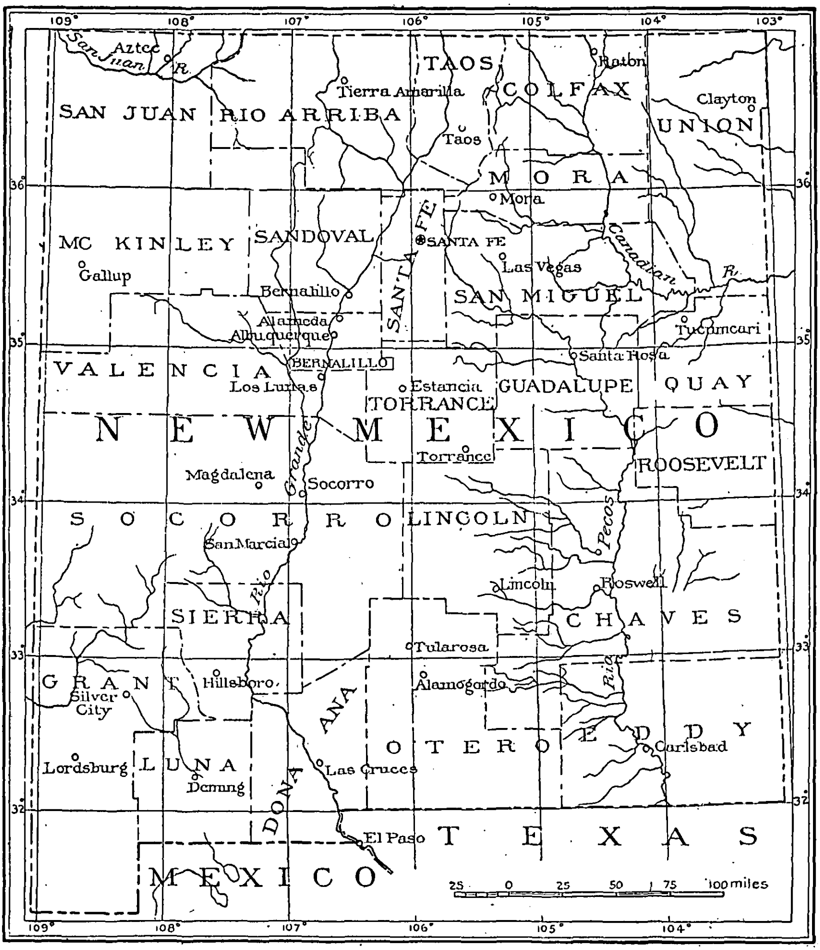

FIG. 4.—Map of New Mexico.

which may be added the group of laccolithic mountains known as the Cerrillos, the Ortiz, San Pedro, and South mountains. On the west are the Ladrone, Limitar, Magdalena, Fra Cristobal, and Caballos mountains. These ranges, which comprise the southern part of the central mountain province, have few features, individually, to distinguish them from many of the desert ranges except in their position as parts of a linear chain of such ranges. There exists, apparently, a transition from the central mountain province to the desert-range province.

East of the central mountain belt the foothills merge into the broad, gentle slopes which form a part of the Central Great Plains of the United States.

THE ROCKS.

The geological features of New Mexico are extremely varied. Beginning with the old pre-Cambrian basement, which here, as to the north, constitutes the cordilleran protaxis of the continent, rocks of almost every period up to the most recent deposits are known somewhere in the Territory. The three great divisions of rocks—igneous, sedimentary, and metamorphic—are abundantly represented.

PRE-CAMBRIAN COMPLEX.

The northern half of the central mountain belt is composed largely of ancient crystalline rocks which can without hesitation be assigned to pre-Cambrian time. The cores of most of the ranges which constitute the southern part of this belt, such as the Sandia, Magdalena, Caballos, and Franklin mountains, are likewise composed of these rocks, as are also some of the ridges in the desert-range province—for example, the Burro Mountains. Red and gray gneisses, which represent sheared granites, are most abundant, although many of these rocks are only a little foliated, and much massive granite is present. Dikes and other intrusive bodies of diorite, gabbro, diabase, etc., have in most cases suffered sufficient shearing and mineral alteration to be converted into dark schistose rocks, which may be grouped together as amphibolite. Extreme foliation of the granitic gneisses frequently results in the production of quartz-sericite schists, and less commonly quartz-biotite schists. Some sedimentary rocks, such as quartz-pebble conglomerates, sandstones, shales, and limestones, also enter into the pre-Cambrian complex and have been metamorphosed more or less completely into schists.

Dikes of pegmatite and aplite cut many of these foliated rocks, but are themselves pre-Cambrian.

SEDIMENTARY ROCKS.

On the basement of old crystalline rocks thick sediments of Paleozoic, Mesozoic, and Cenozoic age have been deposited and have suffered little or nothing from the effects of regional metamorphism. In the north half of the Territory, where the ancient crystalline rocks are overlain by sediments, the Carboniferous strata rest unconformably upon the pre-Cambrian. The most widely distributed sedimentary formations are, therefore, Carboniferous or younger, and the older Paleozoic strata have generally been considered absent, although Cambrian [a] and Silurian [b] have been reported. Representatives of each age from Cambrian to Tertiary, inclusive, are now known to be present,[c] and in the southwestern part of New Mexico Cambrian, Ordovician, Silurian, and Devonian strata separate the Carboniferous beds from the pre-Cambrian. In general these strata succeed each other without apparent unconformity from the beginning of deposition of sediments to the period of eruption at the close of the Cretaceous system. The geological section is by no means complete, however, and in some cases actual unconformities have been observed. These will be mentioned specifically under structure.

Quartzites, often of dark color because of iron stain, containing thin bands of sandy shale and siliceous limestone, are found resting upon the pre-Cambrian gneisses in numerous places in the southwestern part of the Territory. This formation ranges in thickness at various places from about 100 feet to over 1,000. In a shaly layer from the Caballos Mountains Doctor Gordon has found *Lingulella* shells, which unquestionably define this quartzite horizon as Cambrian.

Overlying the Cambrian quartzite without break are 600 to 1,000 feet of limestone, very cherty in the lower half and often much silicified. Fossil fragments suggest that the lower part may be Cambro-Ordovician, while good specimens from higher horizons are certainly Ordovician. This formation has been found in the Caballos and Florida mountains, at Kingston, Hillsboro, Cooks Peak, Silver City, and probably occurs in the Georgetown mining district.

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[a] Yung and McCaffery, Trans. Am. Inst. Min. Eng., vol. 33, 1903, p. 354.
[b] Clark, Ellis, Trans. Am. Inst. Min. Eng., vol. 24, 1894, pp. 138-167.
[c] Cf. Gordon and Graton, Am. Jour. Sci. May, 1906.

In the section west of Silver City the Ordovician limestones are overlain by 200 or 300 feet of limestone which is conformable and similar to those below, but which contains a fauna that is referred by Ulrich to the Silurian. The upper portion of this limestone is the ore-bearing horizon which has been explored by the mines of Chloride Flat. It may be that Silurian rocks are more widely distributed in this part of New Mexico than is at present known.

Black fissile shales of Devonian age overlie the Silurian and Ordovician limestones. In general no stratigraphic break is observable, but Doctor Gordon is of the opinion that there is an unconformity between the Devonian and the underlying rocks at Hillsboro. About 200 feet of these black shales are succeeded in some places by about an equal thickness of red shales, all of Devonian age.

Mississippian (Lower Carboniferous) strata have been found only in the southwestern part of the Territory where the older Paleozoic formations are present. They consist of some 350 to 500 feet of bluish, mostly fine-grained limestone. Where Pennsylvanian rocks overlie the Mississippian they also are mostly crystalline limestones and attain a thickness of several hundred feet. Where the Pennsylvanian beds rest directly on the pre-Cambrian rocks, as is the case in the northern ranges, they consist at the bottom of red conglomeratic arkose or grits resembling granite in appearance and representing rapid erosion and deposition. The upper portions are of crystalline limestone, with occasional thin beds of shales. Beds of coal of promising quality and sufficient thickness to allow mining have been developed to a small extent in these shales along upper Pecos River. This is one of the few known instances of Carboniferous coal in the West. In the northern part of New Mexico these strata are 1,000 feet thick at least and probably considerably more. Much of the "red beds" in the southern and southeastern part of New Mexico, hitherto described as Permian, is probably of Pennsylvanian age; but in the Guadalupe Mountains, according to Girty, occurs a series of rocks which may represent the Permian, and a few imperfect fossils collected at Lone Mountain near Silver City are said by Girty to suggest a "Permo-Carboniferous" horizon, although faulting and igneous intrusions make the stratigraphy uncertain.

The greater part of the red sandstones and shales which cover the Pennsylvanian limestone in the northern half of the Territory have generally been referred to the Jurassic and Triassic systems, although little or no proof is known that they belong there. The lower strata are coarser and more thickly bedded, while the upper portion is generally composed of rather thinly bedded fine-grained sandstones and shales. Some of the beds are gypsiferous. An interesting feature in regard to these "red beds" is the fact, evidenced in a number of places, that they were originally drab or olive-colored rocks and that, contrary to the general belief, their red color has been developed by oxidation since their deposition and consolidation. Yellowish and olive sandstones overlying Pennsylvanian limestones in the southwestern part of New Mexico may also belong here. Step faulting has been prominent in most places where these rocks were observed and makes difficult any estimate of their thickness.

In the northern and eastern parts of New Mexico Cretaceous beds have long been known. Sandstones and shales, belonging, respectively, to the Dakota and Colorado formations, are overlain by the coal measures which are supposed to be of Laramie or Fox Hills age. In the southwestern part of the Territory, Cretaceous rocks have not heretofore been known, but in dark shales some hundreds of feet thick occurring just west of Silver City, fossils have been found which have been identified by Stanton as within the Benton group of the Cretaceous. Similar beds were found farther to the northwest, and all of them are probably of the same horizon as those described from the Clifton quadrangle, Arizona.[a]

Partially consolidated gravels, sands, and marls occur as wash plains and immense alluvial fans at the foot of the higher elevations. Some Tertiary fossils have been found in these beds in the vicinity of Santa Fe, and most of such deposits are accordingly referred to the Tertiary system, while some probably belong to the Quaternary.

[a] Lindgren, W., Geologic Atlas U. S., folio 129, U. S. Geol. Survey, 1905, p. 5.

IGNEOUS ROCKS.

Much massive granite occurs in the pre-Cambrian areas and has therefore already been mentioned. Igneous rocks of post-Paleozoic age are also abundant and in many cases are important because of their intimate connection with ore deposits. There are two distinct groups of these younger igneous rocks—the intrusives and the effusives—although in certain cases intrusive bodies of rocks which otherwise occur principally as flows are known.

The intrusives comprise granite and porphyries. Granite known to be younger than Carboniferous has been found by J. B. Richardson in the Franklin Mountains, where it occurs along faults. In the Organ Mountains a granite cuts Carboniferous strata and at its periphery is decidedly porphyritic. There is no proof that these granites are post-Cretaceous and the fact that pre-Cretaceous, post-Carboniferous granite occurs in the Bisbee [a] district is significant in this connection. On the whole, however, it seems more likely that the Organ Mountains granite at least corresponds in age with the porphyritic intrusives and is post-Cretaceous.

The porphyries in almost all localities are closely related in appearance, being light-gray rocks with prominent white phenocrysts of feldspar. They range in composition from granite-porphyry through syenite-porphyry, quartz-monzonite-porphyry, and monzonite-porphyry to diorite-porphyry. Intermediate types are by far the most common. What may be considered the representative of these porphyries is practically the same rock that occurs in the Clifton copper district. These rocks are of post-Cretaceous age. Important masses of them occur near Red River; at Elizabethtown; in the Cerillos, Ortiz, and San Pedro mountains; at Magdalena, Santa Rita, Hillsboro, and Hanover; and in the Burro Mountains, the Jarilla Mountains, and the Sierra Blanca.

The flow rocks, which are the youngest igneous rocks of the region and cover almost all other deposits, comprise rhyolites, andesites, dacites, and basalts. The rhyolites and dacites are probably most abundant and in places attain a thickness of over 1,000 feet. These rocks, which sometimes contain thin interbedded flows of basalt, are supposed to be of middle Tertiary age. The latest lavas consist of sheets of basalt and are widely distributed throughout the territory. Some of these flows are so recent that the surface is practically unaffected by decomposition or erosion and presents the characteristic broken and ropy appearance of very young lavas.

The older flows are mainly confined to a broad tongue piercing the middle of the Territory from the west as far east as the Rio Grande, although rhyolite is also known in the vicinity of Red River. The younger basalts occur in many places over the northwestern quarter of New Mexico, in various localities east of the central mountain belt, and along the Mexican boundary line west of El Paso.

STRUCTURE.

Of the four factors which have produced the present topography of New Mexico—effusion of lavas, sedimentation, crustal movements, and erosion—the first three appear at first sight to have been by far the most important, while erosion seems to have simply modified the details of their broad effects. But more careful consideration indicates that only by extensive erosion have the effects of crustal movements been exposed and that erosion has prepared the place for sedimentation and surface flows. Erosion therefore is of paramount importance.

Deposition of sedimentary rocks is responsible for the broadest physiographic features of the plateau province and the great plains and the level portions of the desert-range region. Lava flows have in most cases simply veneered over the surface of these plains of sedimentation, but in some instances have mantled and leveled surfaces of erosion.

[a] Prof. Paper U. S. Geol. Survey No. 21, 1904, Pl. XII.

Next to erosion in striking results undoubtedly come movements of the earth's crust. Folding in the strict sense has gone on only to a slight extent in New Mexico, but faulting and doming are exceedingly important.

The Rocky Mountain core is generally believed to have been a land area from pre-Cambrian to near the close of Paleozoic time. This view is sustained in the northern part of New Mexico by the absence of Paleozoic sediments older than the Pennsylvanian series of the Carboniferous. In he southwestern part, however, the sea was present more or less continuously from the beginning of Cambrian time on. At the end of the Lower Carboniferous the northern land area was submerged and sedimentation went on throughout the Territory, possibly with some interruptions, till the close of Cretaceous time. By this time practically the whole Territory was covered by a thick mantle of Cretaceous sediments. Then followed the great crustal movements which left their impress on the present topography. These movements were of two kinds. One was an upthrust of pre-Cambrian rocks along north-south lines, producing longitudinal faulting and bending up the strata on the sides of the ridges so produced. Step faulting with repetition of the strata was a very common result. These phenomena are well shown along both sides of the mountain belt from Santa Fe northward, especially along the upper Pecos and northwest of Las Vegas. Faults undoubtedly bound the steep sides of the Sandia, Manzano, Oscura, San Andreas, Organ, and Franklin mountains. The other movement was brought about by the porphyry intrusions, which formed stocks with some doming of the strata in the Paleozoic sediments and true laccoliths with very decided doming in the Cretaceous sediments. Erosion has since carried away the upper portion of these domes, leaving the igneous rocks exposed. Many instances might be cited. The Cerrillos, Ortiz, and San Pedro mountains are clearly defined laccoliths, while sediments domed by intrusive masses occur in the White Oaks, Elizabethtown, Pinos Altos, and other districts. No local movements of orogenic importance appear to have taken place since these post-Cretaceous movements, for the Tertiary sediments and flows remain practically undisturbed, but a general Tertiary uplift is indicated by the present elevation of the country.

ORE DEPOSITS.

GENERAL FEATURES OF THE MINING INDUSTRY.

New Mexico does not rank very high among the metal-producing States of the West. According to the last report of the United States Geological Survey,[a] the total value of gold, silver, copper, lead, and zinc produced in 1904 amounted to only $2,186,287. On the other hand, the output of coal alone in the same year was about 1,500,000 tons, of a value of $1,900,000. The Territory yielded only $381,930 in gold, of which $149,424 was taken from placer mines. Most of this placer gold came from Colfax County, near the northern boundary line, and from the new diggings in Apache Canyon, in the south-central part of Sierra County. Lode mining of gold ores was carried on chiefly in the Mogollon district and the Rosedale mine in Socorro County, in the Hillsboro district in Sierra County, and in the Silver City district in Grant County, all in the central or southwestern part of the Territory. The silver ores yielded a value of $124,103, the Mogollon district in Socorro County and the Silver City mines in Grant County leading, while Sierra, Luna, and Dona Ana counties contributed smaller amounts.

The copper produced in the Territory had a value of $646,382, the old mines of Santa Rita and the recently developed deposits in the Burro Mountains, both in Grant County, contributing the largest share; Socorro County added an amount of copper valued at $55,316 from the Mogollon district. Lesser amounts came from the Organ Mountains in Dona Ana County and from San Miguel County.

The value of the lead was $134,283, of which the largest part came from the mines in the Organ Mountains in Dona Ana County; smaller amounts were derived from the Cooks

[a] Jones, F. A., Mineral Resources, U. S., for 1904, U. S. Geol. Survey, 1905, pp. 200–203.

Peak mines in Luna County, from the Granite Gap mine and others in Grant County, and from the Magdalena mines in Socorro County. The mining of zinc ores has become an important industry in the Magdalena district of Socorro County and promises to become so in the Tres Hermanas district in Luna County. The metal produced in 1904 is reported as having a value of $899,589, a considerably larger amount than is represented by the silver, gold, copper, or lead industry.

GEOGRAPHIC DISTRIBUTION OF DEPOSITS.

The Great Plains and the Plateau Province of eastern and northwestern New Mexico do not contain metalliferous deposits except local iron and copper ores distributed in sedimentary rocks. On the other hand, the metallic ores are present in every mountain range in the Territory. They occur in the continuation of the Rocky Mountain system in northern New Mexico, in the Zuñi uplift, in the Sandia, Magdalena, San Pedro, Manzano, San Andreas, Oscura, Organ, Mimbres, and almost all of the small desert ranges of southwestern New Mexico. They also occur in the broken-down edge of the Plateau Province about Silver City and in several of the large rhyolite fields in the southwestern part, extending from the Mogollon Mountains into Socorro County.

By far the majority of metalliferous deposits are found in the southwestern quarter of the Territory, and in this area most of the important deposits extend in a curved line from Socorro through Hermosa, Chloride, Kingston, Hillsboro, Lake Valley, Cooks Peak, Santa Rita, and Pinos Altos to Silver City and the Mogollon Mountains near the Arizona line.

There is little indication of any regularity in the geographic distribution of the different metals within the metal-bearing region.

GEOLOGICAL DISTRIBUTION OF DEPOSITS.

Almost every known type of deposit is found in New Mexico. There are ores of copper and iron contained in sedimentary beds; normal, sharply-defined fissure veins, carrying gold, silver, lead, copper, or zinc; wide shear zones, stringer leads, and lenticular bodies of ores, both in intrusive rocks and in the old pre-Cambrian schists; irregular replacement deposits, usually in Ordovician, Silurian, or Carboniferous limestone; irregular-contact deposits, containing copper, lead, and zinc, but usually poor in gold and silver, along the boundaries between intrusive rocks and limestones of any age; and finally gold-bearing gravel beds of Tertiary or recent age.

In a general way the pre-Cambrian schists contain fahlbands, shear zones, and veins of copper and zinc sulphides, low in gold and silver; the Paleozoic limestones are apt to harbor the irregular copper, lead, and zinc deposits, often greatly enriched by processes of oxidation and in places containing much silver; the intrusive porphyries and granites contain fissure veins with gold, silver, or both, and (in most cases) minor amounts of the base metals; and, finally, the flows of rhyolite and andesite inclose, at some places, fissure veins rich in gold and silver, but commonly with relatively small amounts of copper, lead, and zinc.

AGE OF THE DEPOSITS.

In the gold placers, as well as in some of the bedded iron and copper deposits, the valuable metals were introduced or laid down at the same time as the accompanying rock was formed. These deposits are often called syngenetic. The important ore bodies of the majority of New Mexico mines belong to the class of epigenetic deposits, in which the metals were introduced at a time when the surrounding rocks had already been formed. During the present reconnaissance particular attention was given to the question of age, in the hope of discerning the main epochs of ore formation. The results have justified this and it has been shown that certain physical characteristics of the deposits in general distinguish these several epochs, even if the criteria are not always sufficent to determine age in the absence of general geological evidence.

Two principal ages of ore formation have been recognized. The older is pre-Cambrian, while the younger or post-Cretaceous age includes two periods—one late Cretaceous or early Tertiary, and another extending from middle Tertiary practically to the present time.

PRE-CAMBRIAN DEPOSITS.

It is generally admitted that the principal period of ore formation in the Cordilleran region falls within age limits ranging from Jurassic to late Tertiary. That this was preceded by an earlier period is definitely shown in the Black Hills of South Dakota, where Cambrian conglomerates with detrital gold overlie auriferous stringer leads and shear zones in pre-Cambrian schists. It has long been suspected that some Wyoming deposits[a] belong to the same period and according to a recent report by Spencer[b] some of the copper deposits in the Encampment region in Wyoming are surely of pre-Cambrian age, while others, including the principal productive mine, were most probably also formed in that period. The recognition of pre-Cambrian ores in New Mexico justifies the inference that the pre-Cambrian complex of Colorado may contain similar ores, and it is probable that a reconnaissance of Colorado would soon elucidate this question.

As elsewhere in the Rocky Mountain region, a profound unconformity separates the little-altered series of Paleozoic sediments beginning with the Cambrian from a pre-Cambrian complex of granites, gneisses, and various crystalline schists. In northern New Mexico the Carboniferous rests directly upon these oldest rocks, but the Cambrian is present in the southern part of the Territory, as it is in Colorado. There can be no error or misunderstanding in referring to the deposits in question as pre-Cambrian.

The first definite proof of the existence of these old deposits was found at the Hamilton mine on the upper Pecos, 20 miles east of Santa Fe. The deposit contains chalcopyrite and zinc blende and is inclosed in a somewhat schistose amphibolite. Its weathered outcrop is directly and unconformably overlain by nearly horizontal Carboniferous sandstones and limestones. The weathering, which does not extend to a great depth, was certainly effected before the deposition of the covering of the sedimentary rocks.

Many similar deposits occur in the pre-Cambrian of the Santa Fe Range all along up toward the Colorado line. At one of them, situated north of Taos, development work on a large scale has been attempted by the Frazer Mountain Copper Company, and during 1903 a considerable amount of copper, containing some gold and silver, was produced. The evidence of age is not as conclusive in the latter case as it is at the Hamilton mine, but it is very strong.

In the Hopewell and Bromide districts, in Rio Arriba County, narrow stringer veins in altered amphibolite carry copper, gold, and in some places silver, both in the quartz gangue and in the adjoining wall rock. The proof that these deposits are pre-Cambrian is not wholly conclusive.

The pre-Cambrian deposits contain chiefly pyrite, chalcopyrite, and zinc blende; the country rock is usually an amphibolitic or chloritic schist derived from old basic intrusions into the prevailing granites and gneisses; the tenor of gold and silver is ordinarily low—say $3 in gold and 3 ounces of silver. Several types may be distinguished among them: In one the sulphides occur intergrown with the hornblende or other minerals of the containing amphibolite or gneiss and appear to have been formed during the metamorphism of the rocks. In another the ores are contained in more or less irregular or lenticular veins in the schists; quartz is the gangue, sometimes accompanied by tourmaline or garnet. In still another type the copper ores, accompanied by lenticular streaks of quartz and siderite, appear along chloritic shear zones in amphibolitic rocks.

These types strongly recall the description of the Encampment, Wyo., deposits given by Spencer,[c] and in their general appearance they also resemble those upon which the gold and copper mines of the Southern Appalachian States are working.

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[a] In the Silver Crown and Sweetwater districts. See Lindgren, W., The gold production of North America: Trans. Am. Inst. Min. Eng., vol. 33, p. 839.
[b] Spencer, A. C., Prof. Paper U. S. Geol. Survey, No. 25, 1904, p. 56.
[c] Op. cit., p. 53.

Economically they are not very important and have contributed but little to the metal production of the Territory, though some low-grade bodies may be developed into important mines. Placer deposits are connected with some of them, but they are rarely rich.

POST-CRETACEOUS DEPOSITS.

Almost the entire metal production is obtained from deposits of post-Carboniferous age. It is possible that some of these are late Mesozoic, but all of them concerning which we have definite knowledge are later than the Benton (Cretaceous) and range in age almost up to the present time. Without fear of serious error they may be referred to as post-Cretaceous. One of the most positive results of this reconnaissance consists in the accumulated evidence of their geographical and genetical connection with the great igneous activity which manifested itself in this Territory from the earlier part of the Tertiary up to a recent date.

The deposits are divided into two distinct series. The first and earlier is directly connected with great intrusive bodies of acidic porphyries and granitic rocks, and consists of contact-metamorphic deposits, fissure veins, and replacement deposits in limestone. The second and later is connected with the floods of lavas which overwhelmed many areas of this Territory, and consists of fissure veins, probably also replacement deposits in limestone.

EARLIER SERIES.

The deposits connected with the intrusive rocks have thus been separated from those which are in some way allied to the surface flows. It is recognized that in some districts, like southwestern Colorado, erosion has exposed the plutonic rocks which were intruded at lower levels at the time of the effusion of the lavas at the surface. In New Mexico there is no evidence of such deep trenching of the Tertiary lavas.

The intrusive stocks of porphyries and granites are distinctly older than the surface flows and their irruption took place when probably the whole of New Mexico was covered by thick horizontal Cretaceous sediments, forming a pliable and plastic sheet, underneath which the conditions were present for the formation of laccoliths and stocks. Whether the magma broke through this covering or not is not known. A long-continued erosion in many places exposed these intrusives and after this had been done renewed igneous activity followed and surface lavas—andesites, rhyolites, and basalts—covered large areas. The writers would refer the earlier epoch of intrusion to the early Tertiary and the latter epoch of effusion to the middle or late Tertiary.

A review of the deposits of early Tertiary age involves a mention of all the important intrusive stocks of the Territory.

To begin from the north, Colfax County contains a stock of syenitic or granite porphyry, intruded in upper Cretaceous and earlier terranes. Contact-metamorphic deposits mark its periphery at certain places, probably where the Colorado shales are especially calcareous. Garnet, epidote, hematite, and magnetite are the gangue minerals and are accompanied by small amounts of chalcopyrite and in some cases by good values in gold. The same phenomena are repeated in the Cimarroncito district a few miles to the south, where copper is the predominant metal. The igneous rock, as well as the Cretaceous rocks adjoining, are cut by a great number of small auriferous veins, which, though not often workable, have enriched with placer gold practically all the branches of the Cimarron which head in this area.

At Cerrillos, in Santa Fe County, similar intrusive rocks form a smaller stock in upper Cretaceous or Laramie rocks, the sandstone and shale of which have proved less suitable for contact metamorphism. The stock is traversed by a number of northeast veins which carry zinc blende and argentiferous galena and in places extend for some little distance out into the sedimentary rocks.

The Ortiz and San Pedro mountains are small isolated groups a short distance south of Cerrillos and also in Santa Fe County. Both form laccolithic intrusions in Cretaceous and older rocks. Along the contact of the porphyry with the shales baking and contact metamorphism is observed. Along the south contact of the Ortiz Mountains, where calcareous Cretaceous strata adjoin the porphyry, low-grade contact-metamorphic deposits occur, with garnet and chalcopyrite, the latter carrying a little gold. A system of narrow auriferous quartz veins, on one of which the celebrated Ortiz mine was worked, intersects the porphyry of the Ortiz Mountains and has yielded rich placer deposits. The San Pedro laccolith has produced contact-metamorphic copper deposits with economically important ore bodies of chalcopyrite, accompanied by garnet gangue, in Carboniferous limestone. Here again a system of small but rich fissure veins intersects the laccolith and even extends for a short distance into the sedimentary rocks.

At Jarilla, Otero County, a laccolithic mass of porphyry has bulged up the Carboniferous limestones and in certain strata has produced contact deposits carrying gold values, with garnet, epidote, and hematite gangue. In the porphyry and extending out into the sedimentary rocks are quartz veins, some of which carry principally gold and some gold and copper. Erosion of these veinlets has formed the well-known placers at the eastern foot of the hills.

The conspicuous Organ Range in Donna Ana County, east of Las Cruces, is continued southward into the Franklin Range and northward into the San Andreas Range. The Organ Range consists chiefly of granite with associated porphyries, and this granite has been regarded as pre-Cambrian by several writers. This is erroneous, though it is possible that the pre-Cambrian complex may be present in some parts of the range. The granite forms a large laccolithic stock intrusive into Carboniferous limestone and probably continues northward into the little-explored San Andreas Range. For a distance of several miles the limestone is contact metamorphosed, with the development of garnet and payable bodies of now partly oxidized chalcopyrite. Deposits of lead and zinc ores occur short distances away from the contact in the limestone. The granite is traversed by a system of east-west fractures, which contain quartz with gold or silver bearing sulphides.

The small but conspicuous mountain group of Tres Hermanas rises near the Mexican boundary in the southern part of Luna County. In the northerly foothills lead and zinc deposits associated with garnet and wollastonite and of typical contact-metamorphic character have been formed where granite adjoins the Carboniferous limestone. Until recently only lead ores were mined at Tres Hermanas, but lately large quantities of oxidized zinc ores have been discovered. Here again the granite contains a number of narrow quartz veins with silver-bearing lead ores.

Near Hachita, in southern Grant County, the low Apache Hills show irregular intrusions of monzonitic porphyries through Paleozoic limestone. Contact metamorphism with garnet and chalcopyrite is in evidence along the boundary line of the formations, and from one of the deposits, called the Apache mine, oxidized copper ores are shipped, which occur in an extremely coarsely crystalline limestone.

The Hachita Range consists of folded and faulted Carboniferous and probably Cretaceous strata (Comanche formation), with a network of porphyry dikes and sills. Limestone and dikes are cut by a system of northeasterly trending fissure veins which contain galena and zinc blende. In at least one place, "The Copper Dick" mine, where payable copper ores are found, the Cretaceous limestone has been converted into garnet and chalcopyrite.

A large laccolithic mass of porphyry domes up the strata at Santa Rita, Hanover, and Fierro, in Grant County. At the two latter places limestones in contact with the intrusive rock have been metamorphosed and contain low-grade deposits of chalcopyrite, in places with considerable amounts of zinc blende. Garnet, epidote, and magnetite are abundant gangue minerals. Throughout the district ore-bearing fissures occur, principally in the porphyry. In these gold values are generally low, but copper and sometimes lead and zinc are more important. Where little quartz is present and the veins consist principally of narrow streaks of sulphides, secondary enrichment has doubtless played an important part in the formation of ore of workable grade.

Narrow veinlets carrying cupriferous pyrite in porphyry occur in the Burro Mountains. Concentration by descending waters has here likewise probably induced the formation of disseminated chalcocite and has raised the ore to its present grade.

At Pinos Altos, north of Silver City, limestones tilted up by a mass of porphyry are cut by narrow fissures, and replaced along the fissure walls by copper and zinc sulphides. Veins in the porphyry carry copper and gold, with smaller amounts of silver, lead, and zinc.

These phenomena of contact metamorphism with sulphide formation, but without much gold and silver, are repeated from one end of the Territory to the other along the boundaries of intrusive stocks and laccoliths. The contact deposits are almost without exception accompanied by the formation of systems of fissure veins, rich in gold and silver, which chiefly cut the intrusive rock, but also penetrate across the contact. The veins have certain broadly marked characteristics. They are regular, with absence of general brecciation; in the filling quartz predominates and is apt to be coarsely crystalline, sometimes showing comb structure; a banded structure by deposition is rather common. In some cases there may be doubt as to the age of these veins, but enough is known about them to say that as a group they antedate the late Tertiary volcanic flows.

Some of the copper and lead and all of the zinc produced from the ores of the Territory have been derived from contact-metamorphic deposits. A very large part of the gold taken from the Territory has directly or indirectly—by placers—been obtained from the older fissure veins just described. Much silver also comes from this source.

It is certain that the development of these deposits can not be correlated with the ordinary circulation of surface waters, and it appears to the writers that the facts very strongly support the view that the sulphides, as well as the gold and silver, were contained in the intrusive magma; the baser metals were most readily given off at the contacts during the intrusion; the gold and silver deposition was in the main a later process; these metals were concentrated in fissures which were opened in the intrusive rocks shortly after their consolidation, and the veins, like the whole intrusive mass, have been subjected to erosion. At the time of vein formation the presently accessible parts were deeply buried.

A number of irregular lead deposits occur as replacements in the Ordovician or Devonian limestones in Sierra County, the most prominent localities being Cooks Peak, Hermosa, and Kingston; also in Grant County, where the principal producer is at Granite Gap, in the Peloncillo Range In most cases these ore bodies are close to masses of intrusive porphyries, although they are not contact deposits. In some cases they have assuredly been caused by the same waters which filled the fissure veins shortly after the congealing of the intrusive magma.

Several of the large silver deposits of Grant County form irregular replacements of pre-Carboniferous limestone and in most cases are closely associated with dikes or larger bodies of porphyry. At Silver City the ores are found in Silurian limestone immediately below the Devonian shale. At Georgetown and Lone Mountain the limestone just below these shales is likewise the ore horizon. At Lake Valley Doctor Gordon found that a thin bed at the base of the lower Carboniferous (Mississippian) limestones carries the ore. In all these cases the principal ore is the chloride of silver, although partially decomposed galena, rich in sliver, is present in most places.

The important lead, zinc, and copper deposits of the Magdalena Range near Socorro have been studied in considerable detail by Dr. C. H. Gordon, and were also visited by the authors of this paper. The sulphides form replacements in the westward-dipping limestone beds on the western side of the range; associated minerals are magnetite and pyroxene. The deposits are of contact-metamorphic origin and have probably been induced by the intrusion of a granite-porphyry or monzonitic porphyry which outcrops above and below the mines. The deposits are found at the boundary of porphyry and limestone and along particularly susceptible horizons, as below the Silver Pipe limestones. Replacement by sulphides extends up for several hundred feet from the contact.

In some instances veins cutting porphyry are not accompanied by contact metamorphic deposits. In the Jicarilla district, in Lincoln County, narrow seams with gold-bearing pyrite have furnished considerable placer gold. No sediments are known here. At White Oaks well-defined veins and irregular sheeted zones carry rich auriferous pyrite with some quartz. Some of these veins extend into the Cretaceous sediments. At Steeple Rock, in western Grant County, veins in porphyry, carrying gold and some silver, are covered by later flows of rhyolite. No sedimentary rocks were seen here.

LATER SERIES.

The fissure veins in volcanic-flow rocks are the most recent of the epigenetic deposits of New Mexico. These surface lavas are ordinarily easily recognizable as such by their structure, their bedding, and the topography of the terranes. They consist of an older series of basalts, rhyolites, and dacites, less commonly andesites, which cover the eroded surface of the intrusive rocks and the eruption of which took place in middle or late Tertiary time. Still later—in part Quaternary—is a series of basalt flows which is not known to harbor any mineral deposits. The surface lavas cover but a small part of New Mexico. The earlier flows formed the largest volcanic area of the Territory, and connect with the vast lava fields of eastern Arizona. They extend through northern Grant, southern Socorro, and northern Sierra counties, though not without interruption. Smaller areas of them are found elsewhere.

To begin from the north, the first representatives of the fissure veins in surface lavas are found at Red River in Taos County, where they cut rhyolite flows and contain gold with some silver in quartz, calcite, and fluorite gangue. Pyrite and other sulphides are also present. Farther south, at Bland or Cochiti, in Sandoval County, are gold-bearing veins concerning the age of which there is some doubt, but which probably belong to this class. The gold, accompanied by silver sulphides, is present in minute subdivisions in fine-grained almost chalcedonic quartz. Further representatives are the Rosedale veins of gold-bearing quartz occurring in the rhyolite flows of southern Socorro County, and the Chloride, Phillipsburg, Grafton, and Hillsboro veins in Sierra County, which, according to Dr. C. H. Gordon, cut andesite flows and tuffs. Most important of all are the deposits of the Mogollon Range, in the southwest corner of Socorro County, which are believed to have produced several million dollars in gold, silver, and copper. They are brecciated fissure deposits of large size, carrying finely divided gold and silver bearing sulphides in a gangue of quartz and calcite, which has partially replaced the breccia fragments. At the Cooney mine copper minerals, mainly bornite and chalcocite, are associated with quartz, calcite, and fluorite gangue.

There are indications that the vein-forming action during this last epoch has persisted up to a very recent time. At Socorro a system of silver-bearing seams of barite cuts across rhyolite at the base of the escarpment of Socorro Mountain, along which hot springs of considerable volume now issue. The Torrance mine on this belt is said to have produced $200,000. At Ojo Caliente, Rio Arriba County, a small silver and gold bearing vein with fluorite and barite gangue appears to be directly connected with a hot-spring deposit of tufa laid down comparatively recently on the present surface.

Late Tertiary veins are confined to the lava flows of the same age, and there is strong evidence that they were deposited by hot ascending waters shortly after the consolidation of these lavas. The deposits have certain broad, common characteristics; gold and silver are contained in finely divided form, and the former metal has rarely been concentrated into important placer deposits.

Fine-grained, in places chalcedonic quartz is characteristic of many of them, as is often a barite and fluorite gangue. Brecciation of the walls is common, while regular comb or banded structure is rarely encountered. Altogether the veins bear evidence of having been formed close to the surface and of having suffered little erosion since the time of their deposition. A notable quantity of the gold and much of the silver produced by the Territory has been furnished by these veins, though their importance has not equaled that of the older Tertiary series connected with the deep-seated intrusives.

The relations of the New Mexican post-Cretaceous metalliferous deposits to igneous rocks may be concisely formulated as follows:

1. Intrusions of acidic porphyries and granites as stocks and laccoliths normally produced metamorphism and accumulation of sulphides of copper, lead, and zinc, with some gold and silver, in favorable calcareous strata along the contact planes.

2. Shortly after the congealing of the intrusive magmas fissure systems were developed in the stocks and laccoliths, and in these fissures rich gold- and silver-bearing veins were normally deposited.

The contact metamorphic deposits and the veins related to them have been exposed by deep erosion.

3. The eruption and solidification of surface lavas was also followed by fissuring and the deposition of gold and silver bearing veins, but these phenomena were less normal and general than the fissuring of the intrusive stocks. They probably took place only where direct connection with the eruptive focus and with the deep-seated magmas could be established. The veins contained in the volcanic flows have suffered comparatively little from erosion and their present level is thus near the surface of original deposition.

COPPER DEPOSITS IN SEDIMENTARY ROCKS.

Copper is widely distributed through certain sedimentary beds in New Mexico, which are usually referred to as the "Red Beds" and assigned an age varying from Upper Carboniferous or Permian to Triassic or Jurassic. Nor is this development entirely confined to New Mexico, but recurs in the Plateau Province of Utah and Arizona and extends eastward into northern Texas. In their general aspect the distribution and origin of the copper in the "Red Beds" have been discussed by Emmons. [a]

In New Mexico these cupriferous beds are exposed and have been prospected over a broad belt extending across the Territory in a northwesterly direction. The best-known occurrences are at Nacimiento and Cuba, Sandoval County; at Herosa, Rio Arriba County; at Tecolote, near Las Vegas, San Miguel County; and in the Sandia, Manzano, San Andreas, and Oscura ranges in central New Mexico. The localities where most work has been done are at Nacimiento and along the eastern base of the Oscura Mountains. In all cases the copper ores occur partly oxidized, partly as chalcocite in the sandstones. Reduction plants have been erected at Estey, in the Oscuras, as well as at Señorito and Tecolote. Shipments of glance ore have been made from the first two places, but at present these deposits, though certainly extensive, furnish only an insignificant part of the copper production of the Territory.

Opinions are very much divided as to their age and origin. Probably the most prevalent view is that the ores were deposited at the same time as the inclosing sediments by sea or lake water which contained copper in solution. The deposits are not strictly confined to the Permian or Triassic, but occur also in the lowest Cretaceous as well as the in Upper Carboniferous. Our studies of the copper-bearing sandstones have not progressed far enough to justify the expression of a definite opinion concerning them. However, the theory of deposition stated above seems improbable. At least two other possibilities exist: Either the copper was deposited by adsorption in the clayey sandstone of cupriferous solutions ascending on fault fissures, or it was leached from older deposits in adjacent ranges which may have been land areas during the deposition of the "Red Beds," carried down by the streams, and precipitated by processes of adsorption in the sediments near the shores. Leaching and redeposition may even be going on at the present time. Mr. Schrader, who has examined the deposits in the northern part of the Territory, inclines toward this second view. It is also supported by the fact that older pre-Cambrian copper deposits occur in many of the ranges, at the foot of which the cupriferous "Red Beds" extend.

There is evidence in favor of each of these hypotheses. At any rate it seems certain that precipitation by absorption from dilute solutions of copper salts [b] has played an important part in the formation of these bedded copper ores.

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[a] Emmons, S. F., Contributions to economic geology, 1904: Bull. U. S. Geol. Survey No. 260, 1905, pp. 221-232.

[b] Sullivan, Dr. E., The chemistry of ore deposition; precipitation of copper by natural silicates: Economic Geology, vol. 1, No. 1, pp. 67-73.

THE ANNIE LAURIE MINE, PIUTE COUNTY, UTAH.

By WALDEMAR LINDGREN.

Location.—The principal part of the gold and silver mined in Utah is derived from a few camps to the east and south of Salt Lake, such as Park City, Bingham, Mercur, and Tintic. A broad strip comprising nearly half of the State and including almost all of the eastern counties belongs to the Plateau Province and contains few if any deposits of precious metals. This is true also of the southern-central counties, which likewise form a part of the Plateau Province. The western tier of counties, adjoining Nevada, contains among its many desert ranges scattered deposits of gold and silver, but few of them have attained any noteworthy production.

About the year 1900 statements began to appear in the press concerning a new gold discovery of importance in the southern-central portion of the State, in Piute County. This deposit, which is known as the Annie Laurie mine, has amply verified the predictions regarding its value, inasmuch as its production during the last few years amounts to over $2,000,000.

The Annie Laurie mine is situated 175 miles south of Salt Lake City, on the west side of Sevier Valley, in Piute County, just over the line from Sevier County. The region was known to be mineral bearing from the earlier days, for the deposits of Marysvale and Bullion Creek are located in the same vicinity, a few miles to the southeast; but in the new district, which is named the Gold Mountain, no productive mines had previously been developed. The district was discovered about fifteen years ago, but as the ores did not prove amenable to the ordinary amalgamation process, the primitive reduction works erected were a complete failure. With the advent of the cyanide process a method was found which permitted the successful working of the ores, and the present mill was built at the mine by the Annie Laurie Mining Company in the year 1899. The production of gold and silver of the mine since that time has amounted to $2,100,000, or about $400,000 a year.

Development.—The deposit, which is to be classed with the fissure veins, is located at an elevation of about 9,600 feet on the northerly slopes of that cluster of high peaks which culminate with elevations of over 12,000 feet in the Belknap and Delano mountains. The development, which extends over a horizontal distance of 2,400 feet, is effected by four principal tunnels, the upper one called the Blue Bird and the lower three referred to as No. 3, No. 4, and No. 5. The vertical distance between the Blue Bird and No. 5 tunnel is 800 feet. All of the tunnels are crosscuts, and the lowest one penetrates the barren rock for over 3,000 feet until it strikes the vein. In all, the tunnels and crosscuts aggregate several miles in length.

The reduction of the ore is carried on by means of a dry-crushing process, followed by cyanide percolation and amalgamation. The mill, which has a capacity of 200 tons and which is expected to be enlarged to 300 tons, crushes the quartz by four sets of rolls to a 40-mesh screen. The percolation takes place in the usual large tanks and occupies a period of eight days. The amount of sulphides in the ore is exceedingly small, so that concentration on tables is deemed unnecessary. From the cyanide vats the pulp goes to the amalgamating tables, where the coarser gold which may have remained unattacked by the cyanide is finally caught. In the mill now under construction at an adjacent mine by the Sevier Consolidated Gold Mining Company a somewhat different plan is adopted, including concentrating on tables, as well as plate amalgamation and cyaniding.

Geology.—About 100 miles south of Salt Lake City the railroad enters the characteristic Plateau Province, where the strata lie horizontal and little evidence of volcanic action is seen. For 70 miles the road ascends the broad Sevier Valley to its terminus at Marysvale. Cliffs of light-colored reddish or white beds belonging to the Tertiary form a conspicuous wall on the west side, while to the east rises the broad Wasatch plateau, capped by rocks of the same age. Near the town of Richland darker volcanic masses begin to appear on both sides of the valley; their character as flows covering the Tertiary rocks is clearly indicated. This region has been described in considerable detail by Major Dutton in his report on the High Plateaus of Utah.[a] He shows on the west side of the upper Sevier Valley a large area of rhyolite culminating in the peaks of Belknap and Delano, which practically overlook Marysvale. On the east side of the valley the heavy volcanic masses consist, according to Major Dutton, of a trachytic rock.

At the little station of Sevier (elevation, 5,557 feet), a few miles north of Marysvale, the valley contracts, and for a short distance the river flows through a deeply cut canyon in the rhyolitic rocks, evidently excavated since the eruption of the rhyolites, which appear to have formed a temporary dam across the valley. The area indicated on Dutton's map as rhyolite covers at least 1,500 square miles. Over the larger part—that to the north of the higher peaks—the rocks are tuffaceous and more or less clearly water-laid. The wagon road from Sevier to the Annie Laurie mine follows up Clear Creek in a westerly direction between cliffs of well-bedded, light rhyolite tuffs. Eight miles from Sevier it turns southward into the canyon of Mill Creek and from that point rapidly ascends toward the higher central peaks in the range, at the northern foot of which the mine is located. Well up toward the summits the tuff is replaced by massive, light-colored rhyolite, easily breaking into small fragments, which form long white talus slopes along the sides of the ridges. Broad views open toward the north, where the rhyolite tuffs extend for more than 25 miles as a monotonous, high, arid plateau, dotted here and there with a scant vegetation of junipers. From points a short distance north of the mine long and broad but gentle slopes begin, partly covered with bunches of fir and dotted in the autumn with brilliant foliage of aspens and low bushes. These long slopes extend up from the plateau level toward the highest peaks, of which only one, called Bare Mountain, is visible from this point. A number of them exceed 12,000 feet in elevation and are among the highest in Utah. The rhyolite continues almost up to the mine, which is situated at the point where Mill Creek begins to expand into a glacial amphitheater and where the little mining town of Kimberly has obtained a precarious foothold on one of the steep rhyolite slopes. The upper basin of Mill Creek is occupied by a massive greenish-gray rock, much chloritized, and showing small crystals of feldspar. This is the country rock in which the deposits occur. Microscopical examination shows it to contain a considerable amount of quartz in the groundmass, while the phenocrysts are in part alkali feldspar and in part moderately basic soda-lime feldspar. There are also small foils of biotite, usually more or less completely converted into chlorite. On the whole, the rock should probably be classified as a dacite. This area probably extends southeastward across the summit of the range toward Marysvale. Near the Sevier mine and on the ridge between the Sevier and Annie Laurie dikes of dioritic or monzonitic rocks appear. These are dark green and contain no quartz. One of these dikes outcrops close to the Sevier mine, but it is not evident that any close connection exists between the dike and the deposit. The veins are wholly in the dacite.

From the summit a sharp descent leads down toward Marysvale, and in the lower part of Bullion Creek, according to Dutton, outcrops of a quartzite occur, which are referred by him to the Jurassic.

Ore deposits.—The deposits occur in well-defined quartz veins cutting through the core of this old volcanic district. As far as known, no deposits occur in the rhyolite or in the

[a] U. S. Geog. and Geol. Surv. Rocky Mt. Region, 1880.

great masses of rhyolite tuffs to the north of the Annie Laurie. They are confined to the dacite already mentioned as occurring near the mines. The Annie Laurie vein courses nearly north and south and dips from 45° to 60° W. About a mile to the west is a parallel vein called the Sevier, on which the Sevier Mining Company is now erecting a mill. The extension of the Sevier toward the north is being sought for in the Holland tunnel.

The Annie Laurie vein is very poorly exposed on the surface, being largely covered by morainal material. There is, however, a large outcrop rising boldly above the Blue Bird tunnel, and this formed the point of discovery. The vein has not been found on the surface at any point north of this. Within a moderate distance north from the northernmost workings the Annie Laurie vein should enter the rhyolite. How this will affect the deposit is as yet problematical. On the surface none of the productive veins appear to occur in this rock.

The quartz forms an almost continuous sheet along the vein, rarely less than 3 feet in thickness and often expanding to a width of 20 feet or more. As a rule the walls are poorly defined and slickensides indicating motion are rare. In places it contains, parallel to the walls, streaks of iron oxides and black, sooty, manganese ores. Near the walls the vein very commonly shows brecciation, and the quartz here often contains abundant and sharply-defined inclusions of country rock. While it is almost impossible to obtain fresh rock at any place in the mine, and chloritization as well as carbonatization have frequently occurred, the rock is not changed very much in appearance, and the included greenish fragments are sharply outlined against the white quartz.

The mine workings have not penetrated below the zone of oxidation, and neither the quartz nor the country rock seem to contain any unoxidized sulphides. In only one place, in the crosscut of the lowest tunnel, was some fresher dacite found which contained specks of pyrite.

In addition to the regular vein, which is often referred to as the East vein, there is also in certain parts of the workings a smaller fissure which lies a short distance to the west and which differs in some respects from the former. Its quartz contains more gold, its vein is narrower, and slickensides appear sometimes on the walls. It is principally known from No. 3 tunnel, in the richest part of the vein.

Two faults with a throw of 20 and 40 feet are known on the Blue Bird and No. 4 levels, but on the whole the vein is little disturbed.

The ore consists of a white, normal vein quartz, often very friable, breaking easily into small fragments. It is sometimes drusy, but more commonly massive. Calcite is abundant in certain parts of the deposit, but has often been dissolved by surface waters, leaving a hackly or lamellar quartz of striking appearance. As a rule no ore minerals are visible, although on panning the quartz may yield a little visible gold. The pyrite which the ore contained is doubtless converted to limonite, while the decomposition of the carbonates has resulted in the formation of oxides of manganese as well as more limonite. A slight copper stain appears in places, especially where the ore is rich. Finely divided argentite is no doubt present, but only in small quantities. On concentration the ore yields a very small quantity of sulphides, which are extremely rich in silver.

The value of the gold in the ore exceeds that of the silver. Samples of ore of the East vein yield, for instance, gold, $12; silver, $2.30; or gold, $5.60; silver, $2.05. Samples from the West vein contain, for instance, gold, $11; silver, 32 cents; or gold, $4.80; silver, 68 cents. The richest ore is stated to assay from $15 to $18 per ton, odd samples frequently rising to $100 per ton. The average value of the ore is said to be between $7 and $8 per ton. The bullion obtained from the zinc boxes is stated to be 0.925 fine. One analysis shows 230 parts of gold, 695 parts of silver, 65 parts of zinc, and 10 parts of copper, the zinc being derived from the shavings in the boxes. The average bullion would contain about 750 parts silver and 250 parts gold.

The ore of the Sevier mine is in general similar to that of the Annie Laurie, although a drusy structure is more common; in places well-crystallized masses of amethyst-colored quartz appear. It is said that 22 per cent of the gold values and 7 per cent of the silver are recovered on the plates in the amalgamation, which here is the preliminary process. A considerable amount of argentite is present in finely divided form, and panning also yields a little fine gold.

The ore shoots of the Annie Laurie vein have an ill-defined lenticular form when projected on the plane of the vein, and appear to pitch 45° or less to the north. Some of them at least have cores consisting of bunches of rich ore, gradually decreasing in tenor toward the outside. On No. 3 level in the shoot the vein is in places 23 feet wide.

Conclusions.—The ore deposits of the Gold Mountain district possess, in some of their aspects, more than local interest. We find here in the plateau country of southern Utah an isolated volcanic eruption of rhyolite of middle Tertiary age, the central points of which now form some of the highest peaks of the State. Over wide areas around these peaks extend broad plateaus of tuffs—all of them barren of mineral deposits. The ore deposits are found in the focus of igneous activity. On the north side of the peaks lies the Gold Mountain district of quartzose gold-silver ores. On the southeast side, near Marysvale, where the core has been deeply trenched by Sevier River, are the old mining districts of Ohio and Mount Baldy, in which there is but little activity at the present time.[a]

The Annie Laurie, as to country rock, ore, and structure, is an almost exact counterpart of the Waihi deposits in New Zealand, though it does not possess the great number of veins nor the enormous amount of ore exhibited by the latter bonanza. In many respects it is also similar to the De Lamar deposits of Idaho.

These veins are believed to have been deposited by hot springs in fissures as a last phase of volcanic activity shortly after the close of eruptions and not far below the actual surface of that epoch.

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[a] Most of the Marysvale deposits are said to contain lead, zinc, and copper. Selenide of mercury (tiemannite) occurs in the Lucky Boy and other mines in the Baldy district and during 1886 and 1887 was even mined on a commercial scale. In this connection it should be stated that mercury in some form is also reported to occur in the Gold Mountain mines.

SURVEY PUBLICATIONS ON GOLD AND SILVER.

The following list includes the more important publications by the United States Geological Survey on precious metals and mining districts. Certain mining camps, while principally copper producers, also produce smaller amounts of gold and silver. Publications on such districts will be found in the bibliographies for copper on pages 144 and 145 and for lead and zinc on page 166. For a list of the geologic folios in which gold and silver deposits are mapped and described, reference should be made to the table on pages 8 and 13 of the present bulletin:

ARNOLD, RALPH. Gold placers of the coast of Washington. In Bulletin No. 260, pp. 154–157. 1905.

BAIN, H. F. Reported gold deposits of the Wichita Mountains (Okla.). In Bulletin No. 225, pp. 120–122. 1904.

BECKER, G. F. Geology of the Comstock lode and the Washoe district; with atlas. Monograph III. 422 pp. 1882.

—— Gold fields of the southern Appalachians. In Sixteenth Ann. Rept., pt. 3, 251–331. 1895.

—— Witwatersrand banket, with notes on other gold-bearing pudding stones. In Eighteenth Ann. Rept., pt. 5, pp. 153–184. 1897.

—— Brief memorandum on the geology of the Philippine Islands. In Twentieth Ann. Rept., pt. 2, pp. 3–7. 1900.

BOUTWELL, J. M. Progress report on Park City mining district, Utah. In Bulletins No. 213, pp. 31–40; No. 225, pp. 141–150; No. 260, pp. 150–153.

CROSS, WHITMAN. General Geology of the Cripple Creek district, Colorado. In Sixteenth Ann. Rept., pt. 2, pp. 13–109. 1895.

—— Geology of Silver Cliff and the Rosita Hills, Colorado. In Seventeenth Ann. Rept., pt. 2, pp. 269–403. 1896.

CROSS, WHITMAN, and SPENCER, A. C. Geology of the Rico Mountains, Colorado. In Twenty-first Ann. Rept., pt. 2, pp. 15–165. 1900.

CURTIS, J. S. Silver-lead deposits of Eureka, Nevada. Monograph VII. 200 pp. 1884.

DILLER, J. S. The Bohemia mining region of western Oregon, with notes on the Blue River mining region. In Twentieth Ann. Rept., pt. 3, pp. 7–36. 1900.

—— Mineral resources of the Indian Valley region, California. In Bulletin No. 260, pp. 45–49. 1905.

ECKEL, E. C. Gold and pyrite deposits of the Dahlonega district, Georgia. In Bulletin No. 213, pp. 57–63. 1903.

ELDRIDGE, G. H. Reconnaissance in the Sushitna Basin and adjacent territory in Alaska in 1898. In Twentieth Ann. Rept., pt. 7, pp. 1–29. 1900.

EMMONS, S. F. Geology and mining industry of Leadville, Colorado; with atlas. Monograph XII. 870 pp. 1886.

—— Progress of the precious-metal industry in the United States since 1880. In Mineral Resources U. S. for 1891, pp. 46–94. 1892.

—— Economic geology of the Mercur mining district, Utah. In Sixteenth Ann. Rept., pt. 2, pp. 349–369. 1895.

—— The mines of Custer County, Colorado. In Seventeenth Ann. Rept., pt. 2, pp. 411–472. 1896.

EMMONS, W. H. The Neglected mine and near-by properties, Colorado. In Bulletin No. 260, pp. 121–127. 1905.

HAGUE, ARNOLD. Geology of the Eureka district, Nevada. Monograph XX. 419 pp. 1892.

HAHN, O. H. The smelting of argentiferous lead ores in the Far West. In Mineral Resources U. S. for 1882, pp. 324–345. 1883.

IRVING, J. D. Ore deposits of the northern Black Hills. In Bulletin No. 225, pp. 123–140. 1904.

—— Ore deposits of the Ouray district, Colorado. In Bulletin No. 260, pp. 50–77. 1905.

—— Ore deposits in the vicinity of Lake City, Colorado. In Bulletin No. 260, pp. 78–84. 1905.

LINDGREN, WALDEMAR. The gold-silver mines of Ophir, California. In Fourteenth Ann. Rept., pt. 2, pp. 243–284. 1894.

—— The gold-quartz veins of Nevada City and Grass Valley districts, California. In Seventeenth Ann. Rept., pt. 2, pp. 1–262. 1896:

LINDGREN, WALDEMAR. The mining districts of the Idaho Basin and the Boise Ridge, Idaho. In Eighteenth Ann. Rept., pt. 3, pp. 625-736. 1898.

——— The gold and silver veins of Silver City, De Lamar, and other mining districts in Idaho. In Twentieth Ann. Rept., pt. 3, pp. 75-256. 1900.

——— The gold belt of the Blue Mountains of Oregon. In Twenty-second Ann. Rept., pt. 2, pp. 551-776. 1902.

——— Neocene rivers of the Sierra Nevada. In Bulletin No. 213, pp. 64-65. 1903.

——— Mineral deposits of the Bitterroot Range and the Clearwater Mountains, Montana. In Bulletin No. 213, pp. 66-70. 1903.

——— Tests for gold and silver in shales from western Kansas. Bulletin 202, 21 pp. 1902.

——— The production of gold in the United States in 1904. In Bulletin No. 260, pp. 32-38. 1905.

——— The production of silver in the United States in 1904. In Bulletin No. 260, pp. 39-44. 1905.

LINDGREN, WALDEMAR, and RANSOME, F. L. The geological resurvey of the Cripple Creek district. Bulletin No. 254. 36 pp. 1905.

LORD, E. Comstock mining and miners. Monograph IV. 451 pp. 1883.

NITZE, H. B. C. History of gold mining and metallurgy in the Southern States. In Twentieth Ann. Rept., pt. 6, pp. 111-123. 1899.

PENROSE, R. A. F., jr. Mining geology of the Cripple Creek district, Colorado. In Sixteenth Ann. Rept., pt. 2, pp. 111-209. 1895.

PURINGTON, C. W. Preliminary report on the mining industries of the Telluride quadrangle, Colorado. In Eighteenth Ann. Rept., pt. 3, pp. 745-850. 1898.

RANSOME, F. L. Report on the economic geology of the Silverton quadrangle, Colorado. Bulletin No. 182. 265 pp. 1901.

——— The ore deposits of the Rico Mountains, Colorado. In Twenty-second Ann. Rept., pt. 2, pp. 229-398. 1902.

SMITH, G. O. Gold mining in central Washington. In Bulletin No. 213, pp. 76-80. 1903.

——— Quartz veins in Maine and Vermont. In Bulletin No. 225, pp. 81-88. 1904.

SPURR, J. E. Economic geology of the Mercur mining district, Utah. In Sixteenth Ann. Rept., pt. 2 pp. 343-455. 1895.

——— Geology of the Aspen mining district, Colorado; with atlas. Monograph XXX. 260 pp. 1898.

——— The ore deposits of Monte Cristo, Washington. In Twenty-second Ann. Rept., pt. 2, pp. 777-866. 1902.

——— Ore deposits of Tonopah and neighboring districts, Nevada. In Bulletin No. 213, pp. 81-87. 1903.

——— Preliminary report on the ore deposits of Tonopah. In Bulletin No. 225, pp. 89-110. 1904.

——— Ore deposits of the Silver Peak quadrangle, Nevada. In Bulletin No. 225, pp. 111-117. 1904.

——— Notes on the geology of the Goldfields district, Nevada. In Bulletin No. 225, pp. 118-129. 1904.

——— Geology of the Tonopah mining district, Nevada. Professional Paper No. 42. 295 pp. 1905.

——— The ores of Goldfield, Nevada. In Bulletin No. 260, pp. 132-139. 1905.

——— Developments at Tonopah during 1904. In Bulletin No. 260, pp. 140-149. 1905.

SPURR, J. E., and GARREY, G. H. Preliminary report on the ore deposits of the Georgetown mining district, Colorado. In Bulletin No. 260, pp. 99-120. 1905.

TOWER, G. W., and SMITH, G. O. Geology and mining industry of the Tintic district, Utah. In Nineteenth Ann. Rept., pt. 3, pp. 601-767. 1899.

WEED, W. H. Geology of the Little Belt Mountains, Montana, with notes on the mineral deposits of the Neihart, Barker, Yogo, and other districts. In Twentieth Ann. Rept., pt. 3, pp. 271-461. 1900.

——— Gold mines of the Marysville district, Montana. In Bulletin No. 213, pp. 88-89. 1903.

——— Notes on the gold veins near Great Falls, Maryland. In Bulletin No. 260, pp. 128-131. 1905.

WEED, W. H., and BARRELL, J. Geology and ore deposits of the Elkhorn mining district, Jefferson County, Montana. In Twenty-second Ann. Rept., pt. 2, pp. 399-550. 1902.

WEED, W. H., and PIRSSON, L. V. Geology of the Castle Mountain mining district, Montana. Bulletin No. 139. 164 pp. 1896.

——— ——— Geology and mining resources of the Judith Mountains of Montana. In Eighteenth Ann. Rept., pt. 3, pp. 446-616. 1898.

WILLIAMS, A. Popular fallacies regarding precious-metal ore deposits. In Fourth Ann. Rept., pp. 253-271. 1884.