CONTRIBUTIONS TO ECONOMIC GEOLOGY, 1906, PART I.

S. F. EMMONS and E. C. ECKEL, *Geologists in charge.*

INTRODUCTION.

By C. W. HAYES, *Geologist in charge of geology.*

This bulletin is the fifth of a series, including Bulletins Nos. 213, 225, 260, and 285, Contributions to Economic Geology for 1902, 1903, 1904, and 1905, 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 final reports.

The first two bulletins of this series included numerous papers relating to the economic geology of Alaska. In view of the rapid increase of economic work both in Alaska and in the States and the organization of a division of Alaskan mineral resources, distinct from the division of geology, it was in 1905 considered advisable to exclude all papers relating to Alaska. These were brought together in a separate volume entitled "Report of Progress of Investigations of Mineral Resources of Alaska in 1904," Bulletin No. 259. A similar segregation of papers relating to Alaska was made last year (Bulletin No. 284) and will be made this year.

During 1906 a further change in the arrangement of the economic bulletin seemed desirable. The former section of iron ores and nonmetallic minerals was divided, M. R. Campbell being placed in charge of a new section devoted to the investigation of fuels, including coal, oil, gas, and asphalts; and E. C. Eckel remaining in charge of investigations of iron ores, structural materials, and miscellaneous nonmetals.

This change in Survey organization has been used as a basis for a separation of the economic bulletin, based on subjects. The present bulletin (No. 315) therefore covers the work of the Survey in 1906 in the metals, structural materials, and other nonmetals except fuels. A separate bulletin (No. 316) will be issued later covering Survey work on coal, lignite, and peat.

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.

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

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

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

series was commenced in 1902, and the papers are distributed in the same manner as are the bulletins.

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

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

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

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

Circulars containing lists of these folios, showing the locations of the quadrangle areas they describe, their prices, etc., are issued from time to time, and may be obtained on application to the Director of the United States Geological Survey. The following list shows the folios issued 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.
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.

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.
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.
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.

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.
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.
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, *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.

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.
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.
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, 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.

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.
125	Rural Valley	Pa	226	Butts, C	*Coal*, oil, *gas*, fire clay, iron ore, lime, building stone.
126	Bradshaw Mountains.	Ariz	986	Jaggar, 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	do	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	do	227	Woolsey, L. H	*Clay*, coal, *oil*, gas, building stone.
135	Nepesta	Colo	938	Fisher, C. A	Cement, iron ore, oil, gas, gravel.
136	St. Marys	Md.-Va	938	Shattuck, G. B.; Miller, B. L.	*Clay*, gravel, *underground water*.
137	Dover	Del.-Md.-N.J.	925	Miller, B. L	*Clay*, marl, gravel, *underground water*.
138	Redding	Cal	906	Diller, J. S	*Copper*, gold, silver, iron, clay, lime, stone.
139	Snoqualmie	Wash	812	Smith, G. O.; Calkins, F. C.	*Coal*, iron, gold, quicksilver copper.
140	Milwaukee	Wis	219	Chamberlin, T. C.; Alden, W. C.	*Stone*, lime, *cement*, clay, gravel, underground water.
141	Bald Mountain-Dayton.	Wyo	1,699	Darton, N. H.; Salisbury, R. D.	*Coal*, gold, copper, gypsum, stone, phosphate, *underground water*.
142	Cloud Peak-Fort McKinney.	do	1,713	do	*Coal*, gold, copper, gypsum, stone, phosphate, asphalt, *underground water*.
143	Nantahala	N. C.-Tenn	975	Keith, A	*Marble*, *talc*, kaolin, soapstone, mica, corundum, iron, gold.

6. *Mineral Resources.*—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 six volumes of the new series, Mineral Resources of the United States for 1900, for 1901, for 1902, for 1903, for 1904, and for 1905, 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 short papers on economic geology when these are necessary to account for the new developments.

INVESTIGATIONS OF METALLIFEROUS ORES.

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

ECONOMIC PUBLICATIONS OF THE YEAR.

During the year the following publications on subjects connected with the investigation of metalliferous ores within the United States proper have been issued by the Survey:

Professional Papers:

No. 54. Geology and gold deposits of Cripple Creek district, Colorado, by Waldemar Lindgren and F. L. Ransome.

No. 55. Ore deposits of Silver Peak quadrangle, Nevada, by J. E. Spurr.

No. 57. Geology of the Marysville mining district, Montana, by Joseph Barrell.

Bulletins:

No. 293. Reconnaissance of gold and tin deposits of the southern Appalachians, by L. C. Graton, with notes on the Dahlonega mines by Waldemar Lindgren.

No. 294. Zinc and lead deposits of the upper Mississippi Valley, by H. F. Bain.

No. 303. Preliminary report on Goldfield, Bullfrog, and other mining districts of southern Nevada, by F. L. Ransome, G. H. Garrey, and W. H. Emmons.

No. 308. Geological reconnaissance in southwestern Nevada and eastern California, by S. H. Ball.

No. 312. Interaction between minerals and water solutions, with special reference to geologic phenomena, by E. C. Sullivan.

Bulletin No. 312, though not directly the result of geological field work, has an important bearing thereon, in that it is a chemical investigation of some of the problems that come up most frequently in the study of the origin of ore deposits.

REPORTS FOR WHICH FIELD WORK HAS BEEN COMPLETED, BUT WHICH HAVE NOT YET BEEN ISSUED.

Economic geology of the Georgetown quadrangle (together with the Empire district), Colorado, by J. E. Spurr and G. H. Garrey, with a chapter on geology by S. H. Ball.

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

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

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

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

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

Geology and ore deposits of the Franklin Furnace, New Jersey, quadrangle, by A. C. Spencer.

Unexpected and unavoidable delays in the preparation of these reports have been caused by the resignation or illness of the authors. Messrs. Spurr, Garrey, and Weed have resigned their positions on the Survey to accept more remunerative positions with private corporations, and Messrs. Ransome, Boutwell, and Emmons have been incapacitated for work for several months by illness. These causes have also very seriously curtailed the field work during the last season.

FIELD WORK.

GENERAL DISCUSSION.

An important part of the economic investigation of metalliferous ores during the year has been the personal supervision and direction of that part of the work of the division of mineral resources that has to do with metals other than iron. As has already been outlined in previous bulletins, this work has been put under the personal direction of Waldemar Lindgren, who, in training various assistants to carry out its details, has found it necessary to spend the greater part of the field season in collecting and properly differentiating the statistics of gold and silver. Similar supervision and summing up of the statistics of copper has been placed in charge of L. C. Graton and those of lead and zinc in charge of J. M. Boutwell. This work comprises more than a mere compilation of figures furnished by others to show production. It involves the tracing of the metals back to their various sources and the verification, by comparison and analysis, of the necessarily varying results obtained by different lines of investigation. More than that, its object is to gather at the same time such geological data as will enable the geologists in charge of the respective branches of the work to prepare an annual review of the production and prospects of the different metals in their geological as well as their technical and commercial relations, and thus to provide data for an intelligent forecast of the progress of the industries involved and of the direction it is likely to take.

The regular work in the field of metalliferous investigations has been thus curtailed by the time necessarily devoted to the above purposes; also by that lost during the field season through the illness of three important members of the corps, and by the loss, through resignation, of the services of three other members. The increasing exodus of members of the economic force of the Survey in consequence of their employment by large mining organizations at salaries much greater than those they have been receiving from the Government seriously impairs the efficiency of the work of this branch of the Survey. It is only by years of practical experience in the field that the geologist, however excellent his preliminary training, becomes competent to carry on independent work in investigating a mining district, and the loss of trained men in this work is, for a time, irreparable. Since the force available has been thus greatly reduced, the field work carried on during the last season has been very largely in the nature of reconnaissance work and has been confined to the Rocky Mountain region. It will be described, as heretofore, by States and Territories.

ARIZONA.

In Arizona Mr. Ransome commenced in October a special study of the Tombstone district, a once famous silver district that has been reopened in the last few years after a long period of idleness. By the end of the month he had completed a preliminary reconnaissance of the district and started for Nevada, where there is an overwhelming demand for geological examinations of many new districts that are constantly springing into existence; but while examining a geological section on the walls of the Grand Canyon of Colorado River the drum of his ear was accidentally punctured by a twig. What was first thought to be a trivial injury proved later to be so serious that he was obliged to submit to a surgical operation and spent several months in a hospital, where he still remains, incapacitated for work.

CALIFORNIA.

In California L. C. Graton has been occupied during the summer in a special and detailed study of several important copper districts on both sides of the Sacramento Valley in Shasta County. These occur in the highly metamorphosed rocks that characterize the western slope of the Sierra Nevada and present a highly intricate geological problem. During a rather short field season he has been able to complete the study of only one of these areas—the Bully Hill district—a report on which will be prepared for publication during the present office season. Work on the other districts will be resumed in the coming summer. Owing to the pressure of his other work, Mr. Graton has been unable to prepare an abstract of this report for the present bulletin.

COLORADO.

In the San Juan region, as an adjunct to the work being carried on under Whitman Cross, L. H. Woolsey made a reconnaissance examination of mines in the Lake Fork quadrangle, whose deposits constitute the eastern continuation of those in the Silverton quadrangle, already described.

In Boulder County, near the mining town of Eldora, Waldemar Lindgren made an examination of an interesting group of thin veins carrying wolfram, or the tungstate of iron, which now constitute one of the most important sources of tungsten in this country.

In the course of an areal survey of the coal lands to be rendered available by the new Moffat railroad, in and about the valleys of the White and Yampa rivers, Hoyt S. Gale has examined some new deposits of the uranium- and vanadium-bearing mineral, carnotite, which occur in the upturned Dakota sandstones east of the coal basins in Rio Blanco County. These deposits are extremely important as a further possible source of the new metal, radium. Brief reports giving the results of the three reconnaissances mentioned above are included in this bulletin.

MONTANA.

An areal geological survey of the Philipsburg quadrangle, which covers 30 minutes of latitude and longitude, has been carried on during the last summer under the direction of F. C. Calkins. W. H. Emmons was detailed to make an economic examination of this area, which contains numerous important ore deposits. During the summer he completed a field study of the two most important deposits of the region—that worked by the Granite-Bimetallic mine, which is a typical vein deposit, producing silver, and that worked by the Cable mine, which is an auriferous contact deposit in limestone surrounded by granite. A preliminary report on these two mines is given in this bulletin.

NEVADA.

Early in the summer the writer visited the new copper district at Ely, Nev., which promises to become one of the greatest producers of copper in that portion of the country. A railroad 140 miles long was building to develop the district, and large concentrating and smelting plants were planned to treat the low-grade disseminated copper ores in porphyry that have been proved to exist there in large quantities. Preliminary geological reports on the district have already been published in a scientific periodical, and the writer's visit was made simply to determine the area that should be included in a topographical map that will serve as a basis for the special geological study of the district. The topographical survey has since been completed, and it is hoped that it will be possible during the coming season, when the mines shall be actually working, to make an exhaustive examination of the geology and ore deposits of the district.

It has been planned that Mr. Ransome should make a final examination of the Goldfield, Bullfrog, Rhyolite, and neighboring districts in southwestern Nevada, in the light of the latest mining developments, before publishing his report on this region. When it was learned that

Mr. Ransome's accident had incapacitated him for further field work this season, W. H. Emmons was sent to the region after he had completed his field work in Montana, and is now studying the geology of the region at and near Rhyolite. As soon as he is able Mr. Ransome will resume his field work in Nevada, and, it is hoped, will complete the report upon this region before the opening of the new field season. Under the circumstances no abstract of this report has been possible.

OREGON.

In connection with areal work in western Oregon, G. F. Kay has made a new examination of the interesting deposits of silicate of nickel near Riddles, an account of which appears in this bulletin. These deposits have heretofore excited considerable interest because of their close mineralogical and geological resemblance to the famous deposits of New Caledonia, which, up to comparatively recent times, have furnished a large proportion of the world's production of nickel.

The deposits are evidently of secondary origin, but have not yet been found in bodies sufficiently large to be of great economic value. There seems to be, however, no good reason why exploration may not develop ore in amounts large enough to constitute a profitable source of the metal, but such discovery is rather the work of the prospector than of the geologist, since in a region so highly altered it is only by actual mine openings that the localities of ore concentration can be detected.

UTAH.

During the last summer the writer was engaged for a few weeks in studying the geological structure of the western Uinta Mountains, especially of the region around Duchesne River, on the southern flanks of the range--an area that once formed part of the Indian reservation but has recently been thrown open to occupation as mineral land. Deposits of iron ore of good quality and size, as well as small amounts of other metals, have long been known to exist in this region, but no deposit of great economic value has yet been found. The range is remarkable for the entire absence of igneous rocks, the only known occurrence of which are late intrusive sheets in the Mesozoic beds along the Provo Valley, at the extreme western end of the range. All the important deposits of metals except the lead and zinc deposits of the Mississippi Valley are found in regions that are traversed by igneous rocks, and for this reason the Uinta Mountains can hardly, on theoretical grounds, be considered a very favorable locality for the occurrence of these or the more valuable metals. The result of the writer's visit was negative, since he found no evidence of any considerable mineralization.

WASHINGTON.

During the last season A. J. Collier has been occupied, by order of the Secretary of the Interior and in association with an officer of the Land Office, in examining placer lands on the Colville Reservation and along the Columbia and Sanpoil rivers, for the purpose of determining whether certain placer locations were taken up in good faith. He has utilized the geological information obtained during this work for an article on the geological relations of the placer mines of that region, which will be found in this bulletin.

WYOMING.

During an examination of the important iron-ore deposits near Hartville, in Wyoming, S. H. Ball has made some studies of the copper deposits that were worked in this region before the iron ore became valuable. These are of rather unusual form, and Mr. Ball's description, which appears in this bulletin, will be interesting to students of copper deposits.

In connection with an examination of the coal basins in the western part of Wyoming, A. R. Schultz has made a study of gold-placer deposits along upper Snake River and some comparative investigations of placers on the same river in the western part of Idaho. These placers are highly interesting because of the extremely minute particles in which the gold is found—so minute that they evidently must have suffered an immense amount of trituration during the very long journey from their original source in the rocks. Mr. Schultz's article gives an account of the various attempts to work these placers and the results of tests of the black sands collected during the work, which show the character of the various heavy minerals associated with the gold.

INVESTIGATIONS OF IRON ORES, STRUCTURAL MATERIALS, ETC.

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

INTRODUCTION.

During the last year the Survey has carried on extensive investigations in the field included in the work of this section. Some of these investigations are summarized in this bulletin, but a large amount of economic work of this kind has been done in connection with the ordinary areal work of the Survey, and its results appear only in texts accompanying geological folios.

IRON, MANGANESE, AND ALUMINUM ORES.

IRON.

Southern States.—The Survey's work on southern iron ores was carried out in 1906, as in previous years, under the direct charge of the writer. With E. F. Burchard, a detailed study of the Clinton or red ores of the Birmingham district was taken up and practically completed within the field season. The large amount of data generously placed at our disposal by the iron companies of the district will give the final report on this subject peculiar value and will enable us to make a fairly complete report on the iron ores and iron industry of the most important iron district, aside from Pittsburg, in the United States. In the present bulletin Mr. Burchard has discussed, briefly, the more important facts relative to the Birmingham red ores. The present status of Survey work on the iron ores of Alabama may therefore be summarized as follows:

Commercial, geographical, and geological differences permit the separation of the iron ores of Alabama into six groups—

1. The Clinton, red, or fossil ores of the Birmingham district, including ores occurring in the territory tributary to Birmingham from Springville south through Birmingham to the southernmost outcrop of red ore.

2. The red ores of northern Alabama, including ores in territory tributary to Chattanooga, Attalla, and Gadsden.

3. The gray hematites of Talladega and adjoining counties in eastern Alabama.

4. The brown ores of the Russellville district in northwestern Alabama.

5. The brown ores of the Woodstock district, mostly in eastern Tuscaloosa County.

6. The brown ores of eastern Alabama, occurring in a belt extending from the Georgia State line, near Rock Run, southwestward through the Coosa Valley country to near Brierfield.

During the last three years the United States Geological Survey has carried out more or less detailed work in all of these districts. The present bulletin contains reports on the red ores of the Birmingham district, the Russellville brown ores, and the Talladega County gray ores. Preceding bulletins of this series have contained, as noted in the bibliography on pages 213–214, reports on the red ores of northern Alabama and on the Woodstock brown ores. Work on the brown ores of eastern Alabama has been carried on, but the results are not yet ready for publication.

So far as final publications are concerned, a detailed report on the "Iron ores and iron industry of the Birmingham district," by E. C. Eckel and E. F. Burchard, will be submitted for publication as a Survey bulletin in the spring of 1907. The manner in which the other districts of the State will be handled has not yet been decided.

In Tennessee and Georgia work has also been carried on by the Survey on both the red and brown ores, and it is planned to complete certain sections of this work during 1907.

In Virginia work has also been taken up on the iron ores, but for several reasons, notably the lack of good topographic base maps, no attempt has been made to push it to the point of final publication.

Considered from either an industrial or geologic point, the iron ores of Virginia fall into six groups:

1. Magnetites and specular hematites of the Blue Ridge and Piedmont districts.

2. Red hematites (Clinton ores, "fossil ores," "oolitic ores") of the foothills of the Allegheny Mountains.

3. Brown hematites (Oriskany ores) of the Goshen-Longdale-Oriskany district, mostly in Augusta, Bath, Botetourt, Alleghany, and Craig counties.

4. Brown hematites of the New River-Cripple Creek district, mostly in Wythe and Pulaski counties.

5. Brown hematites of the Roanoke, Shenandoah, and Page valleys.

6. Brown hematites ("gossan ores") of Carroll and Floyd counties.

During 1905 and 1906 detailed field work was done on the ores of classes 3 and 4; the ores of class 2 were examined in less detail at several localities in 1905, while on those of classes 1, 5, and 6 no field work was done. It is planned to complete the work during 1907 by examinations of the ore deposits not yet visited.

Pennsylvania-New Jersey.—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 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 done by mining companies has been of a rather haphazard nature, based on no definite working theory. It is hoped that the publication 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.

At the close of work in the New Jersey area Mr. Spencer took up the study of the important and extensive magnetite deposits which occur near the Triassic border in southwestern Pennsylvania. An introductory report on these magnetites of the Cornwall type is included in the present bulletin.

Western States.—Two distinct fields of work have been entered upon by the Survey in its investigation of western iron ores. S. H. Ball spent most of the field season of 1906 in examining and mapping the important Hartville iron-ore district of Wyoming. A brief preliminary report on the results of this work is included in the present bulletin, and a special bulletin on the subject will be published by the Survey during 1907. At the close of this work Mr. Ball made brief examination of the titaniferous iron ores of Iron Mountain, Wyoming, a report on which is presented later in this bulletin.

In Utah C. K. Leith and assistants carried out very detailed mapping of important iron deposits, and the Survey will probably publish the results of this work in a separate bulletin during 1907.

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.

The prosperity of the steel industry has greatly stimulated interest in the subject of manganese ore deposits, and a marked revival of activity has occurred in the well-known Crimora district of Virginia and elsewhere. These developments should be promptly followed up by the Survey, and it is desirable that a preliminary general report on the manganese ores of the United States be prepared and issued as soon as possible.

ALUMINUM AND BAUXITE.

During 1905 bauxite was discovered in Tennessee, Virginia, and Pennsylvania, far north of the deposits previously known. 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 last 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 fulfill entirely 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 the new eastern districts will be surveyed and reported on in the near future.

The recent and proximate expiration of a number of the basic patents on which the aluminum industry is founded has operated to increase greatly the general interest in the supply of ore; and it seems probable that active prospecting and development work will be carried on in all promising districts during 1907.

A reported bauxite field in Arizona was examined during 1906 by C. W. Hayes, whose report is presented in this bulletin.

STRUCTURAL MATERIALS.

Cement.—The geological investigation of cement materials by the Survey during the last year was carried on mostly in connection with the ordinary areal work of the Survey, and its results will be published only in the texts of various geologic folios. An exception to this, however, was the examination of the cement resources of portions of Wyoming by Sydney H. Ball, a report on which is included in the present bulletin. Mr. Burchard has also submitted a brief report on the cement resources near Dubuque, Iowa, for publication in this volume.

Bulletin 243 of this Survey, dealing with the "Cement materials and cement industry of the United States," has been out of print for some time. The demand for it still continues, and it has been decided to rewrite it completely and issue the revised edition in 1907 if possible.

Lime.—In the course of his studies on the areal geology of the Birmingham district of Alabama, Charles Butts collected considerable data on the limestones of that region. In two brief papers published in the present bulletin the principal facts relative to the use of these limestones as fluxing materials and for lime burning are summarized.

Magnesia and magnesite.—During the last fall Frank L. Hess continued his investigations of the magnesite deposits of California. The results of this work are not in shape for publication at present, but a special bulletin on the subject will probably be issued by the Survey in 1907 or 1908.

Gypsum and plasters.—Various gypsum districts have been visited by Survey geologists during the past year, and a report on one western district is contained in the present bulletin. During the coming year an attempt will be made to prepare a revised edition of Bulletin 223, on the gypsum deposits of the United States.

Clays.—A number of reports on the clay resources of various parts of the United States are included in the present bulletin. Most of the investigations covered by these reports were carried on by geologists engaged in areal work for geologic folios, but the work and the papers by Messrs. John T. Porter and Otto Veatch form exceptions to this rule.

Building stone.—T. Nelson Dale has continued his studies of the granite deposits of New England, and is preparing a detailed report on the subject for publication during the coming year as a bulletin of the Survey. The present bulletin includes a brief summary of this report.

MISCELLANEOUS NONMETALS.

Glass sand.—The glass-making materials of several areas were studied by Survey geologists during 1905, and the economic bulletin (No. 285) for that year contained three detailed reports summarizing the results of their investigation. Mr. Burchard continued this work in 1906 and presents two reports in the present bulletin. In the course of this work he has carried out chemical and physical tests, not only of glass sands now in use, but of sands from undeveloped deposits which seem to be available for use as glass-making material. It is believed that this investigation, which is of a type somewhat different from those usually undertaken by the Survey, will yield results so valuable that its continuance is warranted.

Feldspar and quartz.—Reports on the feldspar and quartz deposits of two areas, by E. S. Bastin, are included in this bulletin. These represent, so far as known, the first serious studies of this interesting group of mineral products and will probably prove serviceable to those who are engaged in prospecting or working similar deposits in other districts.

Mica.—Papers on mica deposits in Wyoming and North Carolina, by Messrs. Ball and Sterrett, respectively, will be found in this bulletin. The more detailed of these studies was carried on for the North Carolina Geological Survey and is presented here by permission of the State geologist.

Graphite.—While studying the iron ores of Wyoming, Mr. Ball prepared for this bulletin a brief note on graphite deposits occurring in the same area.

Diatomaceous earth.—Messrs. Arnold and Anderson have prepared for the present bulletin a comparatively detailed report on the extensive deposits of diatomaceous shale which occur in California.

Mineral paints.—During the last year several mineral-paint producing localities have been visited by Survey geologists, and in this bulletin a statement concerning the use for paint of the Clinton or oolitic red hematite ores is presented by Mr. Burchard.

Phosphates and phosphorus.—Several papers included in the present bulletin deal with interesting deposits of phosphates. Mr. Stose describes the manufacture of phosphorus from mineral materials, while Professor Purdue's paper takes up the recently discovered phosphate fields of Arkansas. The paper by Messrs. Weeks and Ferrier describes a new and important phosphate district in the western United States.

Sulphur.—A brief paper on some Utah sulphur deposits, by W. T. Lee, will be found in the present bulletin. So far no detailed study of the sulphur and pyrite deposits of the United States has been taken up by the Survey, though such an investigation and report would be of great industrial interest and value and should receive consideration in the near future.

GOLD AND SILVER.

LAKE FORK EXTENSION OF THE SILVERTON MINING AREA, COLORADO.

By L. H. Woolsey.

INTRODUCTION.

The Silverton mining district, Colorado, has been under development many years and was described by Ransome and others [a] after examination in 1889 and 1900.

What may be considered a geologic extension of this district has been opened near the head of Lake Fork of Gunnison River, at Whitecross post-office, about 14 miles by road northeast of Silverton and nearly the same distance southwest of Lake City. This area was hurriedly covered by a party under Mr. Whitman Cross during a reconnaissance of the San Cristobal quadrangle in the summer of 1906, and the mines, especially those closely surrounding Whitecross, will be discussed in the present paper from field notes taken by the writer at that time.

GENERAL GEOLOGY.

The geology along Lake Fork, as in most of the Silverton area, is that of an intricate igneous complex. Water-laid rocks, save small amounts of fine, stratified tuffs, are the exception. Though many geologic relations were necessarily undetermined during the stay at Whitecross, the broad geologic features of the region may be stated. An indeterminate breccia, consisting largely of monzonitic flow breccias and tuffs and including some fragments of granite, occupies the bottom of Lake Fork for 2 or 3 miles east of Whitecross. This breccia is extensively invaded and covered by a rhyolite bearing prominent quartz phenocrysts, apparently the same rock as that forming large masses on the higher slopes of the valley and especially on the ridges and peaks to the east. To the south this complex lies against a granite backbone, which has, roughly speaking, an east-west extension for several miles along Cottonwood Creek and Lake Fork to the east. Near the mouth of Cottonwood Creek, however, an arm of

[a] Ransome, F. L., Economic geology of the Silverton quadrangle: Bull. U. S. Geol. Survey No. 182, 1903. Cross, W., Howe, E., and Ransome, F. L., Description of Silverton district: Geologic Atlas U. S., folio 120, U. S. Geol. Survey, 1905.

the granite stretches northwestward to Lake Fork at Whitecross and wedges out a short distance beyond the town. The granite is older than the complex, but their present relations are rendered somewhat equivocal through profound faulting and fissuring, which has affected in greater or less degree all the rocks of the area. The fissures follow no single direction, nor do they fall into regular systems, but have a wide range within the northwest and northeast quadrants. Many of them are offshoots of fissure systems lying well within the Silverton area, and in such fissures the ore mined in this locality largely occurs.

MINING.

This region was prospected many years ago and has been the scene of more or less activity ever since; but development is greatly retarded by the lack of transportation facilities. The nearest railroad is at Animas Forks, 5 miles west of Whitecross, but over a divide requiring a 1,500-foot climb. The railroad at Lake City is nearly three times as distant. Nevertheless, from time to time considerable ore has been shipped from the various mines of the region, and active development is progressing as rapidly as the conditions warrant. Many prospects have workings of several hundred feet, and though some were inaccessible at the time of visit such details as were obtainable are given below. The mines are taken up in order from west to east.

The Park View property lies halfway up the southeast face of Edith Mountain, west of Whitecross. Development has been carried on by means of a tunnel over 600 feet long and a 60-foot shaft some distance above the tunnel. The rock at the surface and underground is granite, which is cut by a main southwest fissure. All workings are said to follow this fissure, which is in places several feet wide. The workings were not accessible at the time of visit, but the vein is known to carry chiefly galena, with smaller amounts of gray copper. Quartz is present as the chief gangue mineral and is said to carry some gold.

The Monticello lode is situated at the mouth of Cleveland Gulch, adjacent to Whitecross, and is developed by a shaft 50 feet deep, with a short southward drift at the bottom. Farther up the gulch a new tunnel is also being opened. The surface rock near both workings is granite, and this is the only rock penetrated underground. The shaft and drift were inaccessible, but are said to follow a southwest fissure. The tunnel, however, is on forking lodes, which shoot through the granite in roughly northeast directions. The ore found in the shaft fissure is said to be chalcopyrite and pyrite mixed with calcite and quartz as gangue minerals, and some of this has been shipped in past years. In the tunnel the granite is heavily pyritized near quartz veins, which hold chalcopyrite in large proportions, and at the face ore was observed in three or more veins, covering in all about a foot and a half in width. No postmineral movement was apparent, for the veins had frozen walls. Sufficient ore had not yet been taken from the tunnel to make a shipment.

The two Cleveland tunnels are also situated at the mouth of Cleveland Gulch. They are short and but a few hundred feet apart. The rock in the vicinity, as well as underground, is massive granite. Mineralization is confined to impregnations of pyrite and veins of quartz, but in places these have suffered brecciation and fissuring since their formation. Development has not progressed sufficiently far to expose ore of any account.

The Illinois Boy is an old prospect on the east side of Cleveland Gulch. It is opened by a 250-foot tunnel in granite. Ore like that of the Monticello is said to have been shipped occasionally, but at the time of visit the mine was idle.

The Bon Homme tunnel is situated southwest of Whitecross, on the south slope of the valley. At present it is closed under pending litigation. It is said, however, to have penetrated nearly 2,000 feet of massive granite, which is also the country rock at the surface. In this distance, as reported, it intercepted one of the fissures outcropping on the summit of the hill to the south and locally called the Fanny vein. Ore consisting chiefly of chalcopyrite with quartz is reported from prospects on the vein.

The La Belle tunnel, owned by the Columbus Consolidated Mining and Tunnel Company, is opposite Whitecross post-office, on the south slope of the valley. Development has been carried on through a 650-foot tunnel running due south and a 130-foot crosscut to the southeast. This tunnel is located in a granite area and all the workings are in massive jointed granite. Three thin fissures were intercepted, the first trending east and west and the others shifting to the northeast. All are barren save the last, which is iron stained, but no ore was observed. It is said that the management is driving for a northeast vein that outcrops in the first ravine to the east.

The Silver Star property lies on the north side of the valley a short distance northeast of Whitecross. The workings are very old and at the time of visit were abandoned and inaccessible. Men who have worked in the tunnel, however, agree that it is about 100 feet in extent along a southwest vein. The rock at the surface and also underground belongs to the complex of tuffs and flows which fills the valley to the east. This mine is said to have produced a good grade of copper ore, consisting chiefly of gray copper with chalcopyrite. Specimens taken from the dump confirm this report and show in the vein considerable tetrahedrite and about equal amounts of chalcopyrite and pyrite, with a gangue largely of quartz. The walls are highly silicified fragmental rocks, probably tuffs, through which are sprinkled grains of pyrite and perhaps of tetrahedrite.

The Champion shaft is on the north side of Lake Fork, a few hundred feet east of the Silver Star. The property is now abandoned and the shaft is full of water. Development, however, is known to have been carried to a depth of 160 or 170 feet, with an easterly drift of about 65 feet and one to the west of 30 or 40 feet. The rocks in the vicinity are dark porphyritic flows and fine tuffs, and the material on the dump is largely the same, but its identity is veiled by extensive mineralization. Deformation has produced a fissure trending approximately east and west, which may be observed at the surface and which it is believed the shaft and workings follow. Ore is said to have been taken from this fissure. It was of low grade, however, being valuable for copper, but containing excessive amounts of iron. Specimens collected from the dump, moreover, show the country rock to be greatly altered and silicified and also penetrated by pyrite. The vein material in these specimens contains chiefly chalcopyrite with pyrite and small amounts of galena, quartz and rhodochrosite being the gangue minerals. Of course this does not preclude larger amounts of valuable ore elsewhere in the vein, but the ore heretofore found was probably not valuable enough for profitable exploitation against a heavy flow of water.

The Napoleon shaft is located on the south bank of Lake Fork, nearly opposite the Champion shaft. It also is full of water and abandoned. It is reported to have been sunk 75 feet on an east-west vein. This vein at the surface cuts the igneous complex of flows and tuffs which form both the valley at this point and the country rock of probably the whole shaft. Ore of a good type, chiefly gray copper, is known to have been taken from this vein and shipped, but operations were discontinued because of water.

The Seward County property lies on the north side of the valley, just east of the Champion shaft. The mine is entirely abandoned and very little is known concerning its history. The claim seems to have been opened by short shafts and prospect tunnels, and it is reported vaguely that some gray copper and chalcopyrite ores were shipped years ago. The country rock is similar to that at the Champion, and the workings appear to have followed zones of silification and pyritization probably connected with fissuring.

The great Ohio mine is a mile and a half east of Whitecross, on the east side of Lake Fork, between Cooper and Silver creeks. At the time of visit this property was being more actively developed than any other in the vicinity. Work was progressing in a 200-foot tunnel which intersects an incline shaft from the surface about 100 feet long. A new shaft was also in progress a short distance east of the tunnel. The rock near the workings is commonly the quartz-bearing rhyolite mentioned as intruding and covering the fragmental complex. This proves to be also the rock underground. It has suffered considerable deformation through fissuring along approximately north-south lines, and one of these fissures is followed by the main tunnel and incline shaft. Near the foot of the incline shaft the trend of the fissure is nearly due north, but farther in it turns to the northeast, and though in places it dips very steeply to the northwest or southeast, its general attitude is about vertical. Ore is found in this fissure in rather small shoots, which pitch to the north. Where examined the fissure was not over 3½ feet wide, and the ore was considerably broken, crushed, and mixed with gouge. This indicates strong movement since the deposition of the ore and closer examination shows that the ore occupies the interstices of older fissure breccia and has perhaps slightly impregnated the walls. The ore is chiefly galena and tetrahedrite associated with sphalerite, pyrite, and chalcopyrite, the whole being mixed with vein quartz. Thin sections of the fissure walls studied under the microscope show that mineralization, particularly silicification and pyritization, has penetrated for a considerable distance into the country rock. About 70 tons of ore have been shipped to date, and nearly as much more lies in the bins ready for shipment. The latter is estimated by the manager to contain 12 to 15 per cent copper, $10 to $12 in gold, 50 to 60 ounces in silver, and 10 per cent zinc. Since the fissure has never been followed to any great depth below the tunnel, it seems likely that other shoots, as large as the one excavated, might be uncovered at lower levels. Indeed, since the time of visit it has been reported that ore has been struck in the new shaft which was then being sunk for the purpose of intersecting this and like veins at greater depth.

The O. K. tunnels are located north of Lake Fork and several hundred feet west of Cooper Creek. They are short tunnels upon an east-west fissure system, but seem as yet not to have uncovered ore of any account.

CONCLUSIONS.

Where ore bodies assume a certain mode of occurrence, others of similar character, as a rule, occur in the same locality. Hence, in districts where ore is distributed in veins, as near Whitecross, the likelihood of discovering new veins is strong enough to give high encouragement to the prospector. Such veins, of course, are most evident on barren ridges and summits, but may be no less numerous and valuable, though not so easily found, on forest-clad slopes. Thus in the valley bottoms many lodes may lie in bed rock, hidden by débris, talus, or soil. The uniformly small size of the shoots in this area, however, leads to the expectation that new discoveries will not be more promising than those already made. It would seem that the small veins so far opened, as well as virgin property, might be more successfully exploited by a consolidation of interests. Moreover, the grade of the ore suggests that prospecting should not be carried on in a manner which precludes drainage by gravity.

THE GRANITE-BIMETALLIC AND CABLE MINES, PHILIPSBURG QUADRANGLE, MONTANA.[a]

By W. H. Emmons.

INTRODUCTION.

The Philipsburg quadrangle is a 30-minute area, which joins the south half of the Helena 60-minute quadrangle on the west. Its eastern border is about a mile west of Anaconda, and its northern border is just south of Stone station, on the Philipsburg and Drummond branch of the Northern Pacific Railway. During the summer and autumn of 1906 Messrs. F. C. Calkins and D. F. MacDonald were engaged in mapping the geology of the quadrangle, while the writer studied the ore deposits. The results of this work will be published later by the Survey. It is the purpose of this paper to give a brief description of two of the most important mines.

The thanks of the writer are due Mr. S. F. Emmons, in charge of the division of metalliferous ore deposits of the Survey, for valuable criticism and advice; to Mr. Paul A. Fusz and associates, of the Granite-Bimetallic mine; and to the Messrs. Bacorn and Mr. Adami, of the Cable. The courtesy of all the officers of these mines has made the field work more agreeable and their carefully kept maps and records have made it more effectual than it would otherwise have been. Inasmuch as this paper was written in the field, prior to the study of notes and collections, the writer reserves the privilege to revise statements and conclusions in the final report.

TOPOGRAPHY OF THE QUADRANGLE.

The Philipsburg quadrangle is for the most part mountainous and varies in elevation from 4,600 to 10,600 feet. The central portion of the quadrangle is drained by Flint Creek, which rises near Cable Mountain and flows northeastward to Missoula River. On both sides of this creek is a considerable area of relatively low hills, wooded only in part, which furnish good pasturage for cattle, and in the valley

[a] Preliminary paper, conclusions are subject to revision.

along the streams are a number of hay ranches, where the hardier grasses are cultivated. The higher country is thickly timbered with spruce and pine, sufficient for local needs but of too small size for the outside lumber market.

MINING DEVELOPMENT.

There are several mining camps within the quadrangle, of which the most important are Philipsburg, Cable, Georgetown, Princeton, Combination, Henderson, and Flint. (See fig. 1.) Some of these districts were among the first in Montana to receive the serious attention of quartz prospectors. In 1865 the St. Louis and Montana Mining Company, which was then operating a small smelter at Argenta, Mont., acquired mining claims near the summit of Hope Hill, about 1 mile north of Philipsburg. At great cost this company freighted in a 10-stamp pan-amalgamation mill from San Francisco and installed it at Philipsburg. This mill was still in operation in the summer of 1906, and is said to be the oldest mill in Montana. The Cable mine was discovered in 1866, and since then has been operated a great portion

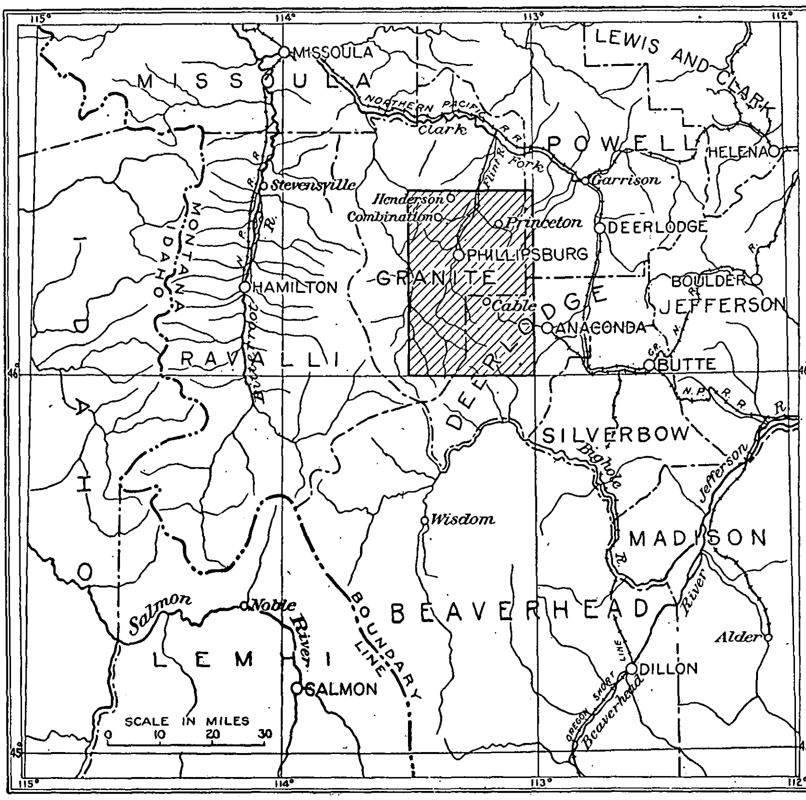


FIG. 1.—Index map showing position of mining camps in Philipsburg quadrangle, Montana.

of the time. The Trout, Algonkian, Two Percent, and a number of smaller mines, a mile or two east of Philipsburg, were opened soon after the Hope, and expensive reduction plants were built at the settlements of Hasmark and Tower near the mines. The annual production of the quadrangle, however, was relatively small until 1884, when the Granite mine, controlled by C. D. McLure and associates, became an important producer. A branch of the Northern Pacific Railway was built from Drummond to Philipsburg in 1887. Encouraged by the success of the Granite, a great deal of prospecting was done on various properties in the district, but none of these fulfilled the promise which they seemed to show except the Bimetallic, which was on the extension of the Granite vein.

The production of the mines in the Philipsburg quadrangle up to the present time is provisionally estimated at $45,000,000 to $50,000,000, more than half of which has come from the Granite mine.

GENERAL GEOLOGY.

The greater portion of the Philipsburg quadrangle is composed of sedimentary rocks which range in age from Algonkian to Cretaceous. According to the estimate of F. C. Calkins the thickness of the pre-Cambrian portion of the section is from 6,000 to 11,000 feet, and that of the later formations from the Cambrian to the Cretaceous is from 5,000 to 6,000 feet. The thickness of the entire section varies from 11,000 to 17,000 feet. Except for a probable angular unconformity between the pre-Cambrian and Paleozoic rocks, the beds are essentially conformable in dip, though unconformities of erosion occur at several horizons. The section, supplied by F. C. Calkins, is given below, the thicknesses being approximate and the correlations in some degree tentative:

Section of sedimentary rocks in the Philipsburg quadrangle, Montana.

	Feet.
Quaternary:	
Fluviatile deposits, consisting chiefly of rounded to subangular gravel and sand, spread on valley bottoms and forming terraces in the vicinity of Philipsburg.	
Glacial deposits: Moraines consisting mainly of granite bowlders.	
Juratrias and Cretaceous:	
Shales, sandstones, and quartzites, with some thin beds of gasteropod limestone	3,000+
Carboniferous:	
Quadrant(?) formation: Mainly quartzite; generally some red spotted shale at base; near Philipsburg a lower bed of pure quartzite separated by a layer of calcareous shale, impure limestone, etc., from an upper bed of less pure quartzite and sandstone; fossils, locally in red shale and limestone	200–500

	Feet.
Carboniferous—Continued.	
Madison limestone—	
Limestone, gray to white, mostly fine grained, rather thick bedded, locally cherty and containing some fairly thick beds of chert; fossiliferous	500
Limestone, fine grained, black on fresh fracture, blue-gray on weathered surface; usually flaggy, contains much chert as irregular concretions; fossiliferous; locally contains a bed of black shale near base	500
Devono-Silurian:	
Jefferson limestone: Massive, mostly white, but with many blue-gray to more nearly black beds; medium grained	1,000
Yogo limestone: Gray to white, medium thick bedded, with closely spaced, thin, siliceous to argillaceous laminæ, and locally a little limestone conglomerate, overlain by flaggy impure limestone, calcareous sandstone, and shale	400
Dry Creek shale: Near Cable, black to olive-green shale with a little gray-green, fine-grained sandstone; near Philipsburg, green to white banded calcareous shale	15–40
Pilgrim limestone: Fine grained, hard, usually cream-white, in part very light gray, locally contains thin beds of shale	200
Cambrian:	
Park shale: Calcareous, light olive-green to dark purplish brown, locally banded, very thin near Princeton and Philipsburg	15–50
Meagher limestone: Medium thick bedded, prevailingly medium grained, light blue-gray, nearly white or dark gray near base, gritty on weathered surface	400
Wolsey shale: Lower part olive-green to black, rather fissile, noncalcareous; upper part banded, calcareous	100–300
Flathead quartzite: Thick bedded, white to reddish, of medium to coarse texture	50–300
Pre-Cambrian:	
Camp Creek formation: Mostly deep-red shale, with some green in thin layers, grading into hard quartzitic reddish to white sandstone, which is very abundant in upper portion; shallow-water features	0–5,000
Blackfoot formation: Calcareous shale, impure limestone, and massive banded calcareous argillite, dark gray to light greenish gray on fresh fracture, weathering buff or yellow, grading into purer gray-weathering limestone, which occurs generally in subordinate amount interbedded with the shale in thin layers and as concretions	4,000
Ravalli (?) formation: Quartzite overlain by purplish and greenish-gray siliceous argillite	1,000
Prichard (?) formation: Bluish-gray argillites largely altered to mica schist, with interbedded sandstone	2,000 +

All the sedimentary rocks, except the glacial and fluviatile deposits, are cut by granite or by granite porphyry. The granite is composed essentially of feldspar, quartz, mica, and hornblende. One large body of it occurs about a mile east of Philipsburg, the western contact passing near the camps of Hasmark and Tower. This same mass extends southward as far as the Red Lion mine and eastward within

2 miles of the Powell mine. Another large boss of granite, not connected on the surface with this one, occurs just west of Cable and extends northwestward to the Southern Cross mine, and thence southward nearly to Silver Lake. An area much larger than either of of these overlaps the eastern border of the quadrangle, its western margin extending in a generally north-south direction from the head of Foster Creek to the head of Gold Creek. The granite of this mass forms the country rock of the Royal mine.

The granite prophyry has about the same composition as the granite, but contains more quartz. It forms several small masses of which the areal extent is insignificant compared with that of the granite. There is a typical occurrence of the granite porphyry about a mile north of Philipsburg, on the east slope of Red Hill.

Where the sedimentary rocks are in contact with the igneous intrusives, the limestones and shales have been greatly metamorphosed. The limestones have been altered to marble, which in many places carries more or less tremolite and white mica. The more calcareous shales have generally been changed to crystalline aggregates, chiefly of garnet and pyroxene accompanied by more or less epidote, amphibole, magnetite, and quartz, while others have been changed to rocks rich in scapolite.

DISTRIBUTION AND GENERAL CHARACTER OF THE ORE.

The most important mining centers are those near Philipsburg, Cable, Combination, and Princeton, but there are a number of isolated mines in the country between these groups, and prospects showing ore are widely distributed over a large portion of the quadrangle. They are most numerous in the intrusive igneous rocks or in the sedimentary rocks near their contacts with the intrusives.

The valuable metals of the ores are silver, gold, and copper. Some of the ores carry considerable zinc and lead, but at present these metals are of no great economic importance to the miner. Magnetic iron ore is mined for flux. Some manganese oxide has been shipped for flux and to a less extent for its manganese content.

The ore deposits occur as fissure veins cutting both the granite and sedimentary rocks; as contact-metamorphic replacement deposits in limestone near the granite; and as replacement deposits in the sedimentary rocks, in part conforming with their bedding planes. From the standpoint of production the fissure veins are the most important. In the granite these are clear-cut fissures with good walls along which there has been practically no replacement of the country rock. In the sedimentary rocks they cut across the bedding at various angles, replacing limestones very irregularly and making large ore shoots at favorable places. The ore bodies of the Cable mine are the only known replacement deposits of contact-metamorphic origin. Several other mines near the Cable are located in the sedimentary rock near the granite contact, but in these mines the ore bodies so far as developed are distinctly replacement veins along fissures. One important group of replacement deposits is that of Hope Hill, where very siliceous silver ore occurs, for the most part as rudely tabular bodies in the bedding planes of limestone, but it also makes out from those horizons as relatively long, curved cylinders, crossing the bedding in all directions.

GRANITE-BIMETALLIC MINE.

HISTORY AND DEVELOPMENT.

The Granite Mountain and Bimetallic mines are about 2½ miles southeast of Philipsburg, on the steep western slope of Granite Mountain, which rises 3,000 feet above the valley of Flint Creek. Although controlled from the first by nearly the same interests and on the same ore shoot, they were worked separately, each with its own reduction plants, until 1898, when a consolidation was effected. Since that time the mines have been operated as one.

The Granite Mountain mine was first located in 1872, but the location was allowed to lapse and in 1875 it was relocated by E. D. Holland, J. W. Estell, and Josiah M. Merrell. In 1880 Charles D. McLure, then superintendent of the Hope mill, encouraged by assay of a specimen picked up from the dump, obtained a bond on the property for $40,000. After spending several thousand dollars in developing the block of ground between what is now level 1 and level 2, with fairly promising returns, he succeeded in organizing a syndicate of St. Louis investors, chiefly from the Hope directorate, who advanced him altogether $132,000. The mine was examined in April, 1881, by Prof. J. E. Clayton, who reported $75,000 worth of ore in sight, the vein being from 4 to 6 feet wide, with an average value of 44 ounces of silver. At this time tunnel (level) No. 1 had been driven 186 feet and No. 2 443 feet, tapping the ore shoot 300 feet from the portal. This ore was iron-stained quartz, carrying a small amount of silver chloride but relatively of low grade. Development work was continued steadily, and in 1882 and 1883 about 1,400 tons from levels 1 and 2 were milled at the Algonquin mill, at Hasmark, 1¼ miles northwest of the mine, a fair saving being made by dry crushing, roasting, and pan amalgamation. As exploration reached greater depth the oxidized ores became higher in grade and sulphide ores extremely rich in silver were found about 200 feet below the surface. Assured of sufficient reserves, the company built at the mine a dry-crushing stamp mill (mill A) with chloridizing roasting furnace, and soon followed it by one of larger capacity, making a total of 80 stamps. At this time the tenor of the ore milled was very high and on level No. 6 an 11-foot face running 150 ounces in silver was left untouched for a considerable period, the mills being occupied with higher grade ore. From 1885 to 1892 the company was extremely prosperous, taking out about $20,000,000 in silver and gold, and paying dividends amounting to over $11,000,000. A third mill, with 100 stamps, was built at Rumsey, 1½ miles south of the mine, and connected with it by a wire tramway, and the Philipsburg and Drummond Railway was extended from Philipsburg to the mill, a distance of 7.7 miles. For a portion of this period the Granite Mountain was the most productive silver mine in the United States.

The property has been skillfully managed since the beginning of development. Specialists of broad training were employed in every department and the thorough organization enabled a high percentage of the output to be paid as dividends to the stockholders. Among the larger owners were Messrs. McLure, Rumsey, Fusz, Clark, Ewing, Filley, Lionberger, Shapleigh, and Taussig, all of St. Louis, and thus through this mine the foundations were laid for many of the larger fortunes of the Middle West.

The Bimetallic Mining Company was organized in 1882, Charles D. McLure, Charles Clark, and J. M. Merrell owning practically all the stock. Its plant was almost a duplicate of that of the Granite. A 100-stamp chloridizing mill was built at Bimetallic, on Douglas Creek about 1¼ miles above Philipsburg. This was connected by rail with the Philipsburg and Drummond Railway and by a wire tram with the hoist house. The mine had a large part of the same ore shoot that was exploited through the Granite, though the ore was hardly so rich. The production of the mine from 1883 to 1893 aggregated about $6,000,000, from which nearly $2,000,000 was paid as dividends. Owing to the fall in the price of silver the mine was shut down in 1893. A consolidation with the Granite was effected in 1898 under the name of the Granite-Bimetallic Consolidated Mining Company, with a capitalization of 1,000,000 shares. At this time the reserves of the Bimetallic mine exceeded those of the Granite, and accordingly the 200,000 Bimetallic shares were transferred for 600,000 shares of the new company, the 400,000 shares of Granite Mountain stock being traded share for share.

After the consolidation extensive improvements were made with a view to working the lower grade ores, of which there was still a large tonnage. An 8,850-foot tunnel from the canyon of Douglas Creek to the mine was completed, draining the Bimetallic mine at a depth of 1,000 feet and the Granite at a depth of 1,450 feet, thus greatly reducing the cost of pumping. A subsidiary organization, the Montana Water, Electric Power and Mining Company, built a reservoir covering several square miles on Georgetown Flat, near the head of Flint Creek, and installed an electric plant which supplied the mines and mills with 1,100 horsepower. A 300-ton concentrator was built just below the collar of the Bimetallic shaft. From 1898 to 1904 the mines produced about $1,000,000 a year. In August, 1905, they were shut down on account of the low price of silver and the decreasing value of the ore. Subsequently they have been reopened above the drain tunnel and the leasing system has been adopted by the company. In the summer of 1906 about 100 men were engaged in the mines and in sorting the old Granite dumps.

The total production of the two mines has been something over $32,000,000 in silver and gold, from which nearly $15,000,000 has been paid in dividends; of this amount the Granite produced more than three-fourths and its dividends have been about $13,000,000. This represents net profits, since the original purchase price and other funds advanced by the syndicate were returned with interest and the extensive hoisting and reduction plants were built from the proceeds of the mine.

The mine was worked from five drift tunnels and two deep shafts, and is cut by a long adit which drains the Granite mine between levels 14 and 15, and the Bimetallic mine at level 10. The Granite (Ruby) shaft is about 1,550 feet deep, and the Bimetallic (Blaine) shaft is about 1,800 feet deep. The vein has been followed and stoped as far as 2,600 feet below the surface and there are altogether more than 20 miles of drifts and crosscuts. At present the mine is under water below the adit level.

GEOLOGY.

The country rock is a medium-grained granite, composed chiefly of feldspar, quartz, mica, and hornblende, which is cut by small aplite dikes. As a rule it is not greatly decomposed in the region of the veins, but is as solid there as elsewhere, although in many places in the walls of the veins the ferro-magnesian minerals have altered to green silicates for a short distance away. A considerable amount of the country rock is included in the vein as angular blocks broken from the walls and at numerous points the vein splits to inclose horses of the granite. The country rock has not been replaced by ore to any great extent, and the granite of the walls or horses can not be worked profitably. The walls are everywhere well defined and make a clear division between the vein and country rock.

ORE DEPOSITS.

General distribution of ore.—The Granite vein strikes about N. 75° E. and its usual dip is about 75° S., although in places it becomes nearly vertical or is even overturned, dipping toward the north. Its width varies from 1 to 20 feet. Along its strike it has been stoped for a distance of 4,500 feet and in depth about 2, 600 feet. As already stated, the vein splits at many places, inclosing horses of various sizes, and here and there smaller veins make off from the principal fissure. Of these the "south vein," which branches from the main lode near the west end of the Bimetallic mine, is the most important, and a considerable portion of it has been stoped with profit. These minor veins do not appear to cross the main fissure, but join it, making angles nearly everywhere of less than 25°, which point toward the west. So far as known, all the minor veins lie to the south of the principal vein. Fig. 2 is a sketch plan of the lode.

In the eastern portion of the mine, on level 8, the vein splits into several branches, the line of separation being nearly horizontal. Below this level two of these branches reunite; others, however, diverge in depth.

The vein probably filled a fault fissure. There was movement along the plane of the vein before the fissure was completely filled and also after it was filled, but the amount of displacement can not be estimated. The fissure can not be identified with faults in the sedimentary rocks beyond the contact of the granite, and where it should

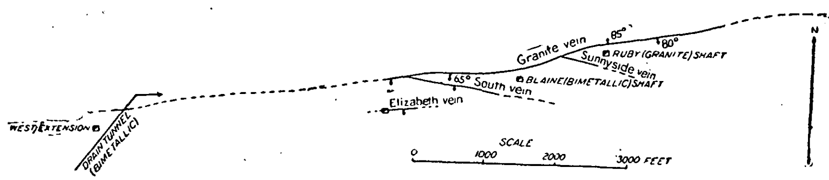


FIG. 2.—Sketch plan of the Granite-Bimetallic lode.

appear, if present, these rocks are not noticeably displaced. Postmineral movement is shown by the local brecciation of the vein and by the slickenside streaks of gouge along the walls. Much of this gouge contains angular fragments of broken quartz, and it is therefore, in part, at least, of postmineral age. That movement occurred while the vein was being filled is recorded by the numerous brecciated fragments of the country rock included in the veins.

So far as is shown by present exposures in the mine none of the postmineral movement has taken place along planes forming any considerable angle with the vein, and although the vein is exposed on many levels for nearly a mile along its strike at no place could cross faulting be detected.

Primary ore.—The primary ore, which is found in the lower portions of the mine, has a gangue of quartz and rhodochrosite inclosing a large quantity of pyrite, arsenopyrite, tetrahedrite, and tennantite, with some galena and zinc blende. Sparingly scattered through this ore are small specks of pyrargyrite, proustite, and here and there realgar and orpiment. This ore carries from 20 to 30 ounces of silver and from $1.50 to $3 in gold. Commonly broad bands of quartz alternate with similar bands of the sulphides, and the banding is parallel to the walls of the vein. In many places the sulphides, chiefly pyrite and arsenopyrite, constitute half the volume of the vein, though quartz is as a rule more abundant than the sulphides. Much of this ore is fractured by movement that has occurred since it was deposited, and many of these fractures are healed by low-grade quartz and rhodochrosite. A seam of gouge, from 1 inch to several inches wide, generally occurs on one or both walls, and this is more pronounced where the vein itself is least fractured. More fragments of the country rock are inclosed in the ore on the lower levels than on the upper ones.

In the lower portion of the mine, about 2,600 feet below the surface, according to authentic records of the company, the vein was as strong and persistent as in the upper levels, and there was no indication that it was decreasing in width, although the values were uniformly low.

Enriched sulphide ore.—The secondary sulphide ore has a gangue of quartz and rhodochrosite, which contain or occur as alternating bands with argentite, proustite, pyrargyrite, tetrahedrite, tennantite, pyrite, and arsenopyrite. Galena and zinc blende are locally abundant; chalcopyrite and bornite are of rare occurrence. This ore carries from 50 to 1,000 ounces of silver and from $4 to $8 in gold. It extends nearly to the surface at one place and has been reported from level 17, but by far the greater portion of it occurs from 300 to 800 feet below the surface. Much of this ore is fractured and in many places the ribbonlike bands are faulted by minute normal and reverse faults, which are as a rule included entirely within the vein. This fracturing appears to have been produced along movement planes, which follow the vein very closely. Probably more than half the silver values of this ore are contained in dark ruby silver, or pyrargyrite, though light ruby silver, or proustite, is also an important ore mineral, as are also tetrahedrite, tennantite, and locally argentite. By far the greater portion of the ruby silver occurs in minute veinlets or seams filling cracks in the vein, as films on the outside of crushed vein material, or as crystals nearly an inch in diameter partially filling solution cavities in the vein. These solution cavities are in general rudely ellipsoidal in shape and, although not connected, their longer axes lie approximately in the same plane, which suggests that they are parts of a larger cavity which has been almost completely refilled. Clear quartz of later age than that of the remainder of the vein and occurring in many places as well-defined crystals pointing to the center of a druse is intimately associated with the ruby silver and like it is of more recent age than the bulk of the vein quartz. The lower portion of the zone of secondary ore does not uniformly carry high values in silver. Between levels 6 and 8 of the Granite, about midway between the

Ruby and Blaine shafts, the vein carried high-grade secondary silver ore, whereas on level 8, just below this ore, it was composed of rhodochrosite and quartz, cut by a large number of veinlets of zinc blende, chalcopyrite, and quartz. Here the rhodochrosite and early quartz is distinctly older than the zinc blende and chalcopyrite, for the vein was opened and locally brecciated in the interim between the deposition of these minerals. At this place the zinc blende and the chalcopyrite are related to the earlier minerals in the same way that ruby silver is above, and appear to play a similar rôle. It is probable that they were deposited at the same time, but that the zinc blende and chalcopyrite were carried down farther at this point by the secondary solutions. By far the larger portion of the dividends which the mine has paid came from the exploitation of the secondary sulphide ore.

Enriched oxidized ore.—Above the zone of enriched sulphides is a zone of enriched oxidized ore, for the most part between the 100-foot and 400-foot levels, but in a few places extending to the surface and at one place extending downward as far as level 9. This ore is composed of quartz stained with iron and manganese oxides and less commonly with copper carbonates. Cerargyrite and native silver occur as thin seams cutting through the quartz or as films plastered on the outside of crushed quartz fragments. Associated with this ore is a little argentite and pyromorphite; galena, zinc blende, pyrite, and chalcopyrite are of local occurrence. This ore runs from 300 to 400 ounces of silver and from $5 to $16 in gold. The value of this oxidized zone is in general less than that of the enriched sulphides.

Poor oxidized ore.—Extending from the surface down, in places as far as 300 feet or more, is a zone of poor oxidized ore, consisting of quartz, for the most part broken and stained with iron and manganese oxides. It contains some lead carbonate, malachite, azurite, chrysocolla, pyromorphite, pyrite, and galena. It carries less than 40 ounces of silver and only a little gold and has never been exploited with profit. This portion of the vein was so unpromising that the claims were once abandoned by prospectors, before the richer ores were discovered.

This oxidized zone has resulted from incomplete oxidation of the secondary sulphides. The apex of this zone, which is the apex of the vein, has been leached of the greater part of its silver and gold values, and this leaching appears to have extended in a few places as far as 400 feet below the surface. The presence of sulphides in this ore, however, shows that even here the oxidation is not complete. Small bunches of galena, with which a little argentite is probably associated, occur here and there in this zone and are unoxidized remnants of secondary sulphides. Some massive low-grade pyrite, which shows no sign of postmineral crushing, occurs similarly at this horizon and may be a remnant of primary ore that was not involved in movement subsequent to veining and was therefore in a position unfavorable to enrichment. The low-grade pyrite crystals which occur locally in druses are of secondary origin and of more recent age than the massive pyrite of the vein.

Distribution of pay ore.—The manner of occurrence of ore in the vein is shown in fig. 3. In this figure no attempt is made to show the horizontal position of the various types of ore in the vein, but the areas show quantitatively the relative amounts of each type of ore at various depths. Each of these zones is cut by zones above it, and the upper zones descended farther where the brecciation of the vein favored the downward circulation of water. The pay ore is practically limited to the enriched oxide and the enriched sulphide zones, though a considerable amount of the low-grade primary ore has been mined.

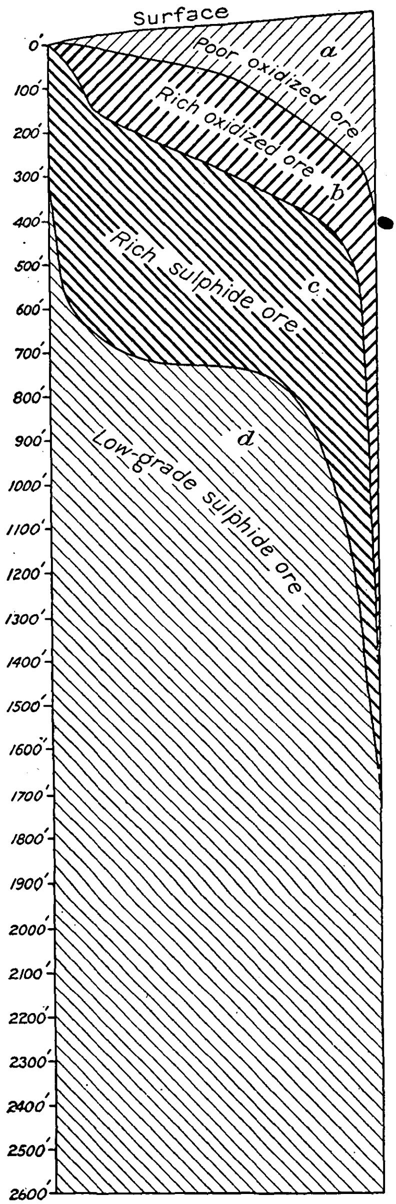


FIG. 3.—Generalized section of Granite vein, illustrating occurrence and association of minerals. *a*, Poor oxidized ore; *b*, rich oxidized ore; *c*, rich sulphide ore; *d*, poor sulphide ore. The horizontal position of the areas representing the various types of ore is without significance as to their position in the vein, but the areas show approximately the relative amount of each type at various depths. The width of the vein is greatly exaggerated with respect to its vertical extent.

The principal ore body is a tabular mass, in the main from 2 to 10 feet wide and about 4,500 feet long. The surface slopes to the west and consequently the greatest depth is obtained in the eastern portion of the mine, where the ore extends downward more than 2,600 feet below the surface. The west end of the ore body has been explored to a depth of about 1,600 feet. Between the eastern and western boundaries the ore is continuous in the upper levels, but in the lower levels a large part of the vein near the central portion of the mine is narrow or of too low grade to work. The form of the shoot of payable ore, therefore, is something like that of a flat arch, the ore pitching in both directions away from the keystone, which is assumed to be about 300 feet west of the Ruby shaft. The rich ore, however, is closely related to the topography of the country and occurs for the most part between 200 and 800 feet below the apex of the vein.

Where other veins unite with the Granite vein along a nearly vertical line, there are no marked effects of enrichment; but the richest portion of the vein occurs just above the union of several veins which joined along a nearly horizontal line. This is the great bonanza, east of the Ruby shaft, between levels 3 and 8.

Probable genesis.—The bonanza ores of the mine are unquestionably the result of secondary enrichment by descending waters; but it can not safely be assumed that the primary ores were everywhere even approximately of equal tenor. The great bonanza east of the Ruby shaft was very much richer than secondary ore occupying elsewhere a similar position in the vein, and probably resulted from primary ore of relatively high grade. The average of the low-grade ore in the lower levels of the mine carries about 25 ounces in silver. The average in the bonanza east of the Ruby shaft, as shown by annual mill runs, was about 175 ounces. This rich zone has an average vertical extent of about 400 feet, and if we assume that it has resulted from the enrichment of a primary ore carrying 25 ounces of silver in a vein of constant width, it would require 6 times 400 feet, or 2,400 feet of 25-ounce vein material, to produce this bonanza, and the original vein before denudation would then have had a vertical extent of at least 5,000 feet. Near the Blaine shaft, between levels 3 and 7, the ore averaged about 100 ounces for a vertical distance of about 350 feet. If this ore has resulted from the enrichment of 25-ounce rock, it would require the erosion of 1,050 feet of the vein from above its present apex, provided all of the values were redeposited. This would give a minimum vertical extent of about 2,850 feet for the original vein here before denudation. There has probably been more than 2,400 feet of erosion since the granite was intruded into the sedimentary rocks, for the Flathead quartzite, the earliest Cambrian formation, now outcrops at the contact with the granite. The entire Paleozoic section above the Flathead, as well as later sedimentary rocks, has probably been eroded from the quartzite since the intrusion. If the vein was formed soon after the solidification of the granite there has been ample erosion to account for any probable amount of enrichment, but as it is likely that the ore east of the Ruby shaft was primarily richer than that west of the Blaine shaft, an estimate below 2,400 feet, so far as the vein itself is concerned, appears to be safer. In either case the vertical extent of the vein was very great, and when this is considered, together with its persistence horizontally and its width in the lower levels of the mine, it appears very probable that the ore was deposited by ascending waters. The veins of the group of which the Granite is the most important member cut both granite and sedimentary rocks, but do not extend very far from the contact. This points to the granite or to some later igneous rock below it as the probable source of the ores.

PRACTICAL DEDUCTIONS.

The country to the north, east, and south of the Granite-Bimetallic lode is traversed by silver-gold veins, which are smaller and of lower grade but otherwise of the same general character as the granite vein. Their strike varies less than 25° from east and west and in most places is a little north of east, approximately parallel to the granite vein. Nearly all dip more than 70° to the south. They traverse both the granite and sedimentary rocks and cross the contact, where they are commonly displaced by faults apparently of small throw. Their walls, like those of the Granite vein, are well defined in the granite but much less sharply defined in the sedimentary rocks, especially in the limestone, where they become replacement veins. At some places they are faulted by cross faults other than those at the granite contact. The Headlight vein, which cuts across the bedding of limestone, is displaced by a number of normal faults that follow the bedding planes of the limestone. The ore minerals are essentially the same as those of the Granite vein, though there appears to be a higher percentage of rhodochrosite in the veins where limestone is the country rock. Near the surface this alters to black manganese oxide, which has been mined to a small extent for that metal. The Trout vein is the most important of this group of silver veins and has produced several hundred thousand dollars' worth of ore.

Of the veins in the granite to the north of the Granite-Bimetallic lode a number have been prospected for more than a thousand feet along the strike, and considerable stoping has been done. None of them, however, has produced much more than $100,000 in silver and gold, and few have paid for the work expended on them. Though they are persistent along their strike, easily followed, and many of them of satisfactory grade, they are in few places of payable width.

From analogy with the Granite vein the depth at which the richest ore should be found in these veins is from 200 to 700 feet below the surface, and the tops of the richest ore shoots should be found not more than 400 feet deep and in most places much nearer the apex of the vein. Considerable prospecting has been done at this depth in secondary sulphide ores. In the country to the northeast and east of the Granite mine there are numerous outcrops of quartz veins that have been prospected only superficially. If there are shoots of rich ore in these veins, their highest point will likely be found almost invariably within 200 feet of the surface, though it is possible that the highest point of some will be 100 or in a few places even 200 feet lower.

In a number of places a sheeted zone of granite, produced by several closely spaced parallel fracture planes and containing a little crushed quartz, has been followed with the hope that the walls of the crushed zone will eventually inclose good ore. There is little basis for such a hope, since the sheeting is to a great extent, and probably in many places entirely, due to movement subsequent to veining.

North of Philipsburg, bordering on the area traversed by the fissure veins just described, are the bedding-plane replacement deposits of Hope Hill. They are of considerable economic importance and have produced several million dollars' worth of silver. These deposits are not discussed in this paper. The structural features of greatest economic importance in connection with them are the post-mineral faults, which cross them at a considerable angle with the bedding of the country rock. By far the greater portion of these faults are normal, which generally implies a downthrow of the hanging wall.

CABLE MINE.

LOCATION AND HISTORY.

The Cable mine is situated near the head of Cable Creek, about 8 miles southeast of the Granite mine and 13 miles northwest of Anaconda. It is 7½ miles above Browns Siding, the terminus of the Butte, Anaconda and Pacific Railway. It was discovered in 1866, and in 1867 the Nowlan mill was built, where 9,000 tons of ore were treated, giving a production of $172,000. According to Government reports the total production of the mine up to 1872 was $400,000. The placer just below the apex of the ore body was very productive, and in 1872 $18,000 was taken out in eight weeks. Some of the ore from the mine was unusually rich, and a single ton is said to have yielded $30,000. A nugget of gold from this mine, worth $375, was shown by Solon Cameron at the Centennial Exhibition.

In 1877, J. C. Savery bought the mine and built a new mill, which was operated until 1891. During this period more than $2,000,000 in gold was taken from the mine. The ore was free-milling and of good grade. Most of it came from the Cornish, Square Set, and Lake stopes, from 100 to 300 feet below the surface.

The ore shoots being apparently exhausted, the mine was idle from 1891 to 1900. Later the management was obtained by F. W. & H. C. Bacorn, who inaugurated a vigorous plan of development with a view to opening up new ore bodies in the lower levels. In their hands a moderate production has been sustained and considerable new ground has been prospected. The total production of the mine since discovery is from $3,000,000 to $4,000,000.

DEVELOPMENT AND EQUIPMENT.

A crosscut tunnel 888 feet long reaches the ore zone about 245 feet below the surface and continues along its general strike for about 2,000 feet. The width of this zone is from 80 to 360 feet, and it has been explored by a large number of crosscuts and raises from this level. There is an engine station about 1,600 feet from the portal of the main adit and a winze from which levels are run 65, 140, and 214 feet below the tunnel level. The lowest workings are a little more than 500 feet below the surface. Above the adit three levels are run from shafts now abandoned, and these workings are connected by stopes and raises with those below. The total development by crosscuts and drifts is about 7,500 feet.

The walls stand remarkably well and very little timbering is necessary. The huge cavities from which the ore has been removed have remained for years without sign of approaching collapse. Of these the Cornish, Square Set, and Showers stopes are above the tunnel level. The Cornish stope is a rudely cylindrical cavity just above the engine station, inclined toward the west about 30°. It is about 50 feet in maximum diameter, 125 feet long, and its top is about 65 feet higher than its base, which is just a few feet above the tunnel level. The Square Set stope is east of and above the Cornish stope, with the top of which its base is connected. Its plan is rudely elliptical and it extends upward within 50 feet of the surface. The Showers stope is about 100 feet west of the engine station, its base being that of the adit level. It is about 30 feet long, 15 feet wide, and 20 feet high. The Lake stope is a few feet north of the engine station and is a long, flat-lying opening, almost cylindrical in shape. It is 320 feet long, 40 feet wide, and from 15 to 30 feet high. Its roof is approximately at the level of the floor of the adit. On the 65-foot level there is a large stope below the west end of the Lake stope and connected with it, and there are several smaller stopes on the lower levels both east and west of the hoist.

The mine is equipped with air compressors, that furnish power for hoist, pump, and drills. Two diamond drills are operated continuously, since it is necessary to prospect the entire ore zone, which has an average width of about 200 feet. The cores, which aggregate several thousand feet, are kept accessible at all times and the records are carefully plotted in the office.

The mill is located just below the portal of the tunnel and is equipped with two Blake crushers and thirty Frazier & Chalmers stamps. A fair saving is made by simple amalgamation, even with the sulphide ores; the extraction is said to run from 80 to 90 per cent. In the autumn of 1896 experiments were made with a view to adding concentrating machinery to the plant. The concentrates, though low in gold, carried sufficient copper and iron to make them a by-product of value.

GEOLOGY.

Country rock.—The ore deposits occur in the Wolsey shale and Meagher limestone. The Wolsey shale is in most places a rather fissile olive-green to black formation from 100 to 300 feet thick. The Meagher limestone is a thick-bedded medium-grained, nearly white to dark-gray limestone, somewhat gritty on weathered surfaces. Its usual thickness is about 400 feet. The Wolsey shale rests upon the Flathead quartzite and in turn is overlain by the Meagher limestone. The relation of these rocks with later ones is given in the geologic section (p.p 33–34).

These formations have been cut by two intrusive masses of granite in such a manner as to form a long narrow belt of sedimentary rocks, chiefly Meagher limestone, closely confined between granite walls. The southwestern granite mass covers an area of several square miles and extends nearly to the Southern Cross and Gold Coin mines. This granite body forms the south wall of the ore zone. The northern intrusive is much smaller and its outcrop is relatively long and narrow, so that its form suggests that of a dike approximately parallel to the contact of the larger mass. These two intrusives are in the main from 50 to 360 feet apart, and though each sends off small apophyses toward the other, connection between the two has not yet been found. The strike of the ore zone, as determined by the granite contacts which limit it, is about northwest. The attitude of the sedimentary rocks in the mine can not everywhere be made out, but their general strike is probably close to that of the ore zone and, locally at least, their dip is nearly 90°. The granite is medium grained and composed essentially of feldspar, quartz, mica, and hornblende. It is in most places fresh and very much resembles the granite that forms the country rock of the Granite mine, near Philipsburg, though the two bodies are not connected in outcrop.

Contact metamorphism.—The sedimentary rocks are greatly metamorphosed near their contact with the granite. The upper part of the Wolsey formation is a calcareous shale and changed very readily to a rock composed chiefly of pyroxene, amphibole, garnet, magnetite, epidote, and mica. Rocks of this composition outcrop on the surface north of the ore zone, and angular masses of garnet rock more than a foot in diameter occur at several places in the lower levels of the mine. They are especially numerous on the north wall of the 214-foot level. The contact-metamorphic minerals, especially garnet and epidote, are in many places concentrated along the bedding planes of the altered shale to a certain extent, and this is also true of pyrite.

The Meagher limestone has been extensively recrystallized near the granite intrusive, and within the entire ore zone it has been changed to a marble of which the grain varies greatly. The commonest facies is a white or light-gray marble composed of interlocking grains of calcite that are a little smaller than grains of wheat. Very commonly this grades into a marble composed in the main of interlocking crystals of calcite several inches in diameter. As the grain of the marble increases a considerable proportion of quartz, iron oxides, and iron and copper sulphides begins to appear, and in the coarsest varieties these minerals are as a rule present in considerable quantities. The coarsely crystalline calcite occurs throughout the ore zone, but is most abundant near the granite contacts.

Magnetite is present throughout the ore zone as large, irregular bodies that have apparently no relation to the bedding planes of the rocks. These bodies are confined to the limestone and occur on all levels. The magnetite bodies are rudely ellipsoidal in outline, and some of them are at least 100 feet in diameter. One of the larger masses lies just west of the engine station and forms in part the west wall of the Cornish stope.

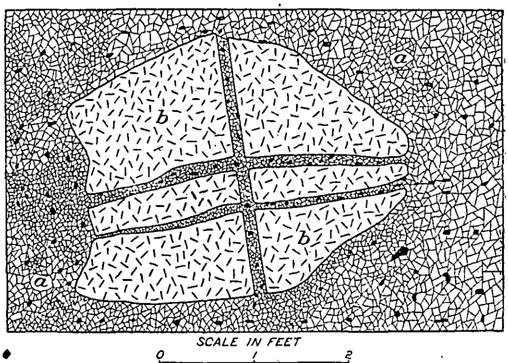


FIG. 4.—Granite block surrounded and cut by coarsely crystalline calcite, quartz, pyrite, and chalcopyrite, 40 feet below northwest end of Lake stope, Cable mine. *a*, Calcite, quartz, pyrite, and chalcopyrite; *b*, granite.

Mica veins.—Veins composed of green mica occur in many places at the contact between granite and limestone or magnetite and limestone, and apart from the contact they have been noted cutting the magnetite. These veins are from 1 to 3 inches wide and are composed of crystals of green mica about an inch in diameter. They are probably of pegmatitic origin and are of later age than the granite and the magnetite, and they may represent an end phase of the granitic intrusion.

Age relations.—The general relations of the various rocks, as shown by their contacts, can be briefly stated. Shale and limestone are the earliest rocks, and limestone is cut by granite and magnetite and by veins of mica pegmatite. Granite cuts the sedimentary rocks only and does not cut magnetite. Magnetite cuts limestone and probably follows the granite in age. The mica veins cut all the other rocks and are therefore of later age.

The recrystallization of the limestone continued after the granite had solidified and had been fractured. Numerous veins of the calcite cut the granite. Fig. 4 shows a block of granite 40 feet below the northwest end of the Lake stope; it is about 3 feet in diameter and is completely surrounded by coarsely crystalline calcite containing quartz, pyrite, and chalcopyrite and is cut by veins of the same material from 1 to 3 inches wide. Similar veins cut the limestone and more sparingly the magnetite. The coarsely crystalline calcite grades into the limestone and commonly the contact is frozen so tightly that in milling it is necessary to treat a considerable amount of barren limestone with the calcite ore.

Fissures.—Fissures, later than the ore, cross the ore zone at several places. On the tunnel level, 250 feet southeast of the engine station, a fault striking N. 70° E. dips to the east about 70°. East of the fault the southern contact of granite and limestone has moved about 18 feet to the north. Other fissures cut across the ore zone at various angles, but the displacement along them is not great. Most of these fissures carry a few inches of gouge, but are not mineralized. There are also faults of earlier age than these, but later than the granite intrusion. It is not possible to follow these earlier fissures in the coarsely crystalline calcite on account of complete recementation, and they are probably more numerous than they appear to be. The brecciation of the tongues of granite is of the same age as this fissuring, which probably occurred soon after the granite became hard but before it became cold, since there was much recrystallization afterwards. These fissures are healed by coarsely crystalline calcite and quartz; the principal ore bodies do not appear to be related to them, however, but are altogether irregular in outline.

ORE DEPOSITS.

General character.—The ore deposits are large, irregular bodies of calcite and quartz, containing a large amount of mixed iron and copper sulphides and iron oxides. These are confined to a long, narrow zone of limestone and calcareous shale that trends southeastward and is bounded by two granite intrusives, the walls of which are steeply inclined, nearly parallel, and from 80 to 360 feet apart. The nonmetallic minerals are calcite, quartz, barite, and dolomite, of which calcite is most abundant. The original metallic minerals are pyrite, chalcopyrite, pyrrhotite, arsenopyrite, magnetite, specularite, and gold. Marcasite should perhaps be placed in this class, also. The secondary metallic minerals are hematite, limonite, manganese oxide, siderite, malachite, azurite, chrysocolla, bornite, chalcocite, gold, and copper.

In most of the ore of the lower levels calcite, quartz, pyrite, and chalcopyrite are interlocking, irregular bodies, which apparently were deposited at one time. When a magnet is passed over the crushed ore, there is nearly always a separation of magnetite and pyrrhotite. Though the source of the calcite is the limestone or country rock, the calcium carbonate has migrated to a certain extent and has been redeposited with the other minerals.

Gold occurs finely disseminated in calcite, quartz, pyrite, pyrrhotite, and chalcopyrite, as large nuggets associated with these minerals or, less commonly, as thin sheets following the cleavage of calcite.

In the table on page 55 comparisons are made of the minerals of the Cable and Granite-Bimetallic mines.

As already stated, the valuable ore deposits are confined to the sedimentary rocks. The calcite stringers which cut the granite are small and of low grade and have never been considered of economic value. The ore is so irregularly distributed in the sedimentary rocks that the entire zone is regarded as the vein, and must be prospected from wall to wall by crosscuts and drill holes in order that no ore bodies shall be overlooked. This ore zone strikes southeastward, is rudely tabular and nearly upright, and has been partially explored underground for about 1,800 feet along its strike; on the surface it appears to extend farther northwest along the same general course; its vertical extent is unknown, but has been proved for about 600 feet. On the tunnel level the walls or granite boundaries are for the most part about 240 feet apart and nearly parallel. The contact plane of the north wall dips 80° to 90° NE. The plane of the south wall is very irregular and from the tunnel level, near the engine station, has a low dip northeastward to the level 65 feet below, so that at this point the ore zone is only about 80 feet wide. Below the 65-foot level the contact dips again to the southwest, so that the ore zone is about 125 feet wide below this point, on the 214-foot level.[a] The outline of the ore zone is irregular also on account of the small tongues of granite that project into the limestone and the blocks of granite that are portions of such tongues detached and broken by subsequent movement.

The recrystallization of the limestone into medium-grained or coarser marble is general; and in this metamorphism the entire ore zone was involved. The formation of the coarse calcite or ore may have occurred, to a considerable extent, along structural lines, such as planes of early movement and bedding planes, but if so these were apparently so irregular and complex that they can now be traced only in exceptional cases and then only for short distances. On the 214-foot level in at least one place the ore followed for a short distance what appeared to be the original bedding planes of the limestone. That the coarsely crystalline calcite or ore in some places follows lines of movement is shown on the tunnel level, just east of the entrance to the Lake stope. Here three flat, nearly horizontal bodies of granite occur at different elevations and in positions which show them to be

---

[a] Recent drilling shows that it is much wider than this east of the shaft on this level.

broken pieces of a larger mass; the lines of faulting by which they were separated have been entirely obliterated and the blocks are now surrounded by coarse calcite; the planes where the faults once passed show no signs of movement, but are completely recemented by coarse calcite, in every way resembling that which surrounds the granite blocks elsewhere. Since the faulting, the recrystallization has been complete.

The primary ore is the coarse calcite carrying a variable amount of quartz, pyrite, chalcopyrite, pyrrhotite, arsenopyrite, magnetite, hematite (specularite), and gold. These minerals appear to have been deposited at the same time and each of them has been noted in the lower levels of the mine. The metallic minerals as a rule occur as irregular masses in the spar and quartz, but locally as bands alternating with them. In this ore the gold is for the most part finely disseminated in the rock, but rich ore containing masses of gold larger than a grain of wheat has been found on the lowest level of the mine. Some of the larger bodies of gold may be of primary origin. A mine specimen as big as a walnut contains about half pyrrhotite and half gold. The association of oxides and sulphides is common in all of the ores from all parts of the mine. In the lowest level copper ore is found in which films of bornite and chalcocite coat masses of chalcopyrite. There is a considerable quantity of this ore along the north granite contact on the 214-foot level.

The oxidized ore has so far proved the richest of the mine. This occurs near the tunnel level and in the ground above it and is characterized by a large amount of hematite and limonite. It contains more silica and less calcite than the sulphide ores. Some of the oxidized ores from the upper workings carried considerable copper, and several thousand tons of tailings from ore milled years ago, before the present mill was built, were found to pay handsomely when smelted for their copper content. The average of analyses of seven cars of these tailings shipped to the Anaconda smelter is as follows:

Average analysis of tailings from the upper and partly oxidized ores in Cable mine.

Silver	ounces per ton	0.15
Gold	per ton	$2.97
Copper	per cent	3.06
Insoluble matter	do	19.1
FeO	do	38.3
CaO	do	10
Moisture	do	11.2
CO_2 (estimated)	do	8

Tailings from sulphide ores milled later and from lower levels do not carry such high values in copper, so it appears that there was a copper-enriched zone in the upper part of the mine. The sulphide copper ore on the 214-foot level is, however, still richer in copper than the tailings from the ore near the surface.

Distribution of ore in the deposits.—The distribution of ore in the ore zone is extremely irregular. The largest and richest body of ore was the Cornish ore shoot, a rudely cylindrical mass inclined from the horizontal toward the west, and occupying approximately the Cornish stope, described on page 46. Above this and connected with it is the Square Set ore shoot, which continues upward at a steeper angle to the surface. The Showers ore shoot, about 100 feet west of the engine station, is in line with the other two, but a large irregular body of magnetite is situated between them. The magnetite forms the northwestern boundary and a part of the base of the Cornish ore body. The three ore bodies appear to be connected to the south of the magnetite body by coarsely crystalline calcite and quartz. The plane of these ore bodies is near the center of the ore zone and makes a small angle with its strike, trending more nearly east and west. Still another group of ore bodies occurs to the north of this one, lying close to the north Granite contact. It is not connected by ore with the Cornish group. Of the northern group the Lake ore shoot is by far the largest and most productive. The shape of this ore body was nearly that of a thin cylinder about 320 feet long—approximately the shape of the Lake stope, described on page 46. Its northwest end is connected by low-grade sulphide ore with an ore body just below and a little farther north on the 65-foot level, below which there are still others on the 140-foot and 214-foot levels. In these, however, the ore does not extend eastward as far as in the Lake ore body. All the ore bodies of this group are closer to the northeast wall than to the southwest wall and are north of and below the Cornish group. The Square Set and Cornish stopes are connected by ore, as are the Lake stope and the stope on the 65-foot level. If the central point of each of the ore bodies is plotted not more than three such points fall in approximately the same plane. Since any three points have a common plane, it is clear that the ore bodies are not related to a plane like ore shoots in a fissure vein. The ore occurs in general a few feet away from the granite, and only in the Lake stope and its continuation on the level below did the stoping extend to the granite. Owing to the close confinement of the ore zone between the granite walls no point in the zone is more than 200 feet from granite.

Genesis of the ore.—The form and general character of the ore bodies show that they are replacement deposits. They can not be classed as replacement veins or stocks, for their boundaries are approximately cylindrical or rudely spherical, and a single ore body does not extend very far in any one direction. Taken as a whole they show little or no alignment.

Of the minerals of contact-metamorphic origin amphibole, calcite, garnet, mica, and epidote are present in the ore zone; but of these, so far as can be determined megascopically, calcite alone is intimately associated with or is a part of the ore. Among the primary ore minerals those characteristic of deposits of contact-metamorphic origin are pyrite, pyrrhotite, chalcopyrite, magnetite, and specularite. In many respects the ore bodies resemble the copper deposits of the Clifton-Morenci district in Arizona, for which Lindgren has proved a contact-metamorphic origin.[a] So far as the ore itself is concerned the association of minerals is much the same. The chief difference is that the Cable ores carry considerable gold and less copper than those of the Clifton-Morenci district. The bodies of magnetite, the mica veins, and the ore deposits all appear to owe their origin to the intrusion of the granite. The magnetite represents a phase of contact metamorphism when substitution was complete or nearly so. The mica veins probably represent an end phase of igneous intrusion, since they occupy slip planes which were made after the granite had become hard and after the magnetite bodies had formed. The coarsely crystalline calcite, carrying ore, has resulted partly from substitution and partly from recrystallization of the country rock. Silica, iron, sulphur, copper, and gold were added and some lime was probably removed. This ore has certainly been extensively recrystallized since the granite became hard enough to break. Fault fissures that cut both granite and calcite have been completely healed in the calcite in such a manner that their presence would not even be suspected if this rock alone were exposed. Small calcite veins also cut the granite. Though the substitution or replacement probably occurred while the granite was still soft, recrystallization on an extensive scale continued after it had solidified.

PRACTICAL DEDUCTIONS.

The granite comes in contact with limestone at several places around Cable Mountain, and bodies of magnetite similar to those of the Cable mine are not uncommon. Near the granite at several places are ore deposits in limestone that are of considerable importance; but these, so far as present developments show, are not of the same type as the Cable, being replacement veins of very irregular width, yet clearly related to fissures. The ore is much the same as the oxidized ores of the Cable, the ore minerals being limonite, hematite, specularite, and magnetite, with a little pyrite and pyrrhotite. The values are chiefly in gold. They are almost invariably largest and richest at the bend of a fissure or at the intersection of two fissures.

Iron-oxide gossans are very common in the vicinity of Cable Mountain, but in most places they carry very low values in gold or are barren. These iron caps have resulted from the oxidation of an ore

[a] Lindgren, W., Copper deposits of Clifton-Morenci district, Arizona: Prof. Paper U. S. Geol. Survey No. 43, 1905, pp. 126-164.

composed in part of pyrite, for many of them contain pseudomorphs after that mineral. The gold of the replacement veins, so far as they have been developed, is finer than that of the Cable mine, and there are no placers of importance. Good ore bodies have been found below barren or low-grade gossans; but thus far the highest points of the ore shoots have everywhere extended within 50 or 100 feet of the surface and at most places nearer. The trend of these veins can usually be made out by trenching or by digging shallow pits. The most favorable place for prospecting is at the intersection of two veins.

Much of the magnetite carries from 20 to 80 cents a ton in gold, and at some places it has been prospected with the hope that in depth it will change to a sulphide ore carrying gold of payable grade. The large bodies of magnetite, however, are unquestionably of primary origin and will continue to be magnetite as far down as they extend. The pyrite ore of the veins alters to limonite and hematite, carrying small grains of magnetite and nowhere to large masses of magnetite. The presence of the small magnetite grains in the oxidized ore has no diagnostic value, for they are present in the oxidized ore of practically every ore deposit in the Philipsburg area, and a large number of these are ordinary fissure veins and in no sense replacement deposits.

RÉSUMÉ.

The Granite-Bimetallic lode is a typical fissure filling of simple structure and of remarkable persistence both horizontally and vertically. Surface waters have leached the values from its apex and to a variable depth of 50 to 300 or 400 feet below the surface. Below this zone is one of enriched oxidized ores in which the values are largely horn and native silver. Next below is a zone of enriched silver sulphides, unquestionably of secondary origin, and the primary ore, the deepest in the vein, is a low-grade sulphide ore carrying silver and gold.

The Cable ore body is a contact-metamorphic deposit of rather uncommon character, but resembles most such deposits in having no definite shape. The country rock is for the most part limestone and has undergone the usual change due to contact metamorphism. The ore minerals, aside from the presence of considerable coarse gold, are those commonly associated with ores of contact-metamorphic origin. As a rule the ore is not immediately at the contact of the granite, but may occupy any position in the ore zone.

So far as their larger structural features are concerned the ore deposits of the two mines are so unlike that they can scarcely be compared. A list of nearly all the minerals noted in the two mines, with short notes upon their occurrence or position in the deposits, is given in the subjoined table. This list was made previous to microscopic study, and other minerals should doubtless be added to it. Forty minerals or varieties are noted. Of these 25 per cent are peculiar to the Cable, 25 per cent peculiar to the Granite, and 50 per cent are common to both mines.

Comparison of minerals in the Granite-Bimetallic and Cable mines.

Minerals.	Granite-Bimetallic mine (a silver-gold fissure vein in granite), 2,600 feet deep.	Cable mine (a gold-copper contact-metamorphic deposit in limestone and shale at contact with granite), 600 feet deep.
Oxides.		
Limonite	In upper levels	In upper levels.
Hematite	do	Do.
Specularite	None	Throughout the mine.
Magnetite	Sparingly present in upper levels	Very abundant on all levels.
Manganese oxide	Considerable in upper levels	A little in upper levels.
Native metals.		
Gold	Finely divided throughout the mine.	Large nuggets chiefly in upper workings; small anhedra on all levels.
Silver	In upper levels	No native silver noted.
Copper	None	A little in upper levels.
Carbonates.		
Calcite	Very sparingly present	Very abundant on all levels.
Rhodochrosite	Considerable	None.
Siderite	None	A little.
Dolomite	A little	Do.
Malachite	In upper levels	In upper levels.
Azurite	do	Do.
Sulphate.		
Iron sulphate	Common as crystals on walls	Common as crystals on walls.
Sulphides.		
Pyrite	Abundant	Abundant.
Pyrrhotite	None	At many places.
Marcasite	do	A little.
Chalcopyrite	A little	At many places.
Bornite	do	Do.
Argentite	At many places	Some.
Chalcocite	Little or none	A little.
Arsenopyrite	Abundant in lower levels	A little in lower levels.
Ruby silver (pyrargyrite and proustite).	At all depths below 200 feet, but less abundant in lower levels.	None.
Gray copper (tetrahedrite and tennantite).	In lower and middle levels	Do.
Galena	At many places	Rare.
Blende	do	Do.
Realgar	Here and there	None.
Orpiment	do	Do.
Silicates.		
Quartz	Very abundant	Much less abundant than in Granite-Bimetallic mine.
Rhodonite	At many places	None.
Chrysocolla	In upper levels	In upper levels.
Actinolite	None	At many places.
Wollastonite	do	Here and there.
Garnet	do	Do.
Green mica	do	At many places.
Epidote	do	Here and there.
Kaolinite	Abundant	Not so abundant as in Granite-Bimetallic mine.

GOLD-BEARING RIVER SANDS OF NORTHEASTERN WASHINGTON.

By Arthur J. Collier.

INTRODUCTION.

The occurrence of finely divided gold associated with magnetic iron in the sands of Snake River, in Idaho, is well known, and published reports describing these deposits and the methods of mining and collecting the gold have frequently appeared. Information regarding the presence of similar gold along the Columbia and other of its tributaries is not so general, though such occurrences have been known locally for many years.

From twenty to thirty years ago placer claims were worked at many points along the upper Columbia by Chinese,[a] but since the exclusion of Chinese laborers these old mines have been abandoned and the evidences of them are obscured by a growth of young pine trees. Mining was resumed to a certain extent by white men during the hard times of 1893 and 1894, when, as reported, scant wages could be obtained, but in later years the attempts to extract this gold have been sporadic and usually ineffectual. Interest in these deposits has recently been revived by the location, ostensibly for placer-mining purposes, of many large tracts of bench land adjacent to Columbia and Sanpoil rivers in the Colville Indian Reservation.

During the past season an investigation was made by Mr. F. M. Goodwin, of the General Land Office, and the writer, to determine whether or not these locations were made in good faith. This investigation was confined to 100 miles of the Columbia Valley from Nespelem to Kettle Falls and to the Sanpoil Valley below Republic, but much of the resulting information is believed to be of sufficient general interest to warrant publication.

GEOGRAPHY.

The Colville Indian Reservation lies in the northeastern part of the State of Washington, north of Columbia River, which bounds it on the east and south sides. This river flows southward from the Canadian

[a] Symons, Thos. W., Rept. on Examination of Upper Columbia River: Senate Ex. Doc. No. 186, 47th Cong., 1st sess., Washington, 1882, pp. 27-28.

boundary for about 90 miles to its junction with Spokane River, where it turns sharply and flows westward for 80 miles to the mouth of the Okanogan, which has a southerly course from the Canadian line and forms the western boundary of the Reservation. Sanpoil River flows across the reservation, also in a north-south valley, joining the Columbia about halfway between the Okanogan and Spokane. At the mouth of the Okanogan the Columbia again turns to the south and, a short distance beyond, to the east, flowing in that direction to its junction with Snake River and partially surrounding an extensive plateau region known as the Big Bend country.

The Colville Reservation comprises about 2,000 square miles, a large part of which is agricultural and timber land, nearly all of the remainder being valuable for grazing. It is only partially settled by Indians, is ill supplied with wagon roads, and is not reached by rail, though an electric line is under construction from Spokane to the Columbia at the mouth of Spokane River, and several surveys have been made and rights of way located for a railroad through the Sanpoil Valley.

Columbia River below Kettle Falls is navigable by steamboat except for a rapid at the mouth of Spokane River.

The Big Bend country south of the reservation is nearly all in cultivation. It is traversed by the Great Northern and Northern Pacific railways. The region east of the reservation is also well settled and is reached by the Spokane Falls and Northern Railway. The country between the Colville Reservation and the Canadian boundary was formerly included in the reservation and has been open to settlement for only a few years. Republic, its principal town, is at the head of Sanpoil River and is the terminus of a branch line from the Canadian Pacific Railway.

TOPOGRAPHY.

The Big Bend country which lies south of Columbia and Spokane rivers is a plateau 2,000 to 3,000 feet above the sea, characterized by slightly rolling topography and here and there traversed by dry canyons called coulees. This plateau is mantled by fine-grained, light-colored soil and comprises a large part of the wheat lands of Washington.[a]

North of Columbia and Spokane rivers the topography is more diversified. Although upland-plain surfaces are not lacking, these are surmounted by two ranges of higher hills which extend north and south on either side of the Sanpoil and which attain maximum elevations of about 9,000 feet near the northern boundary of the reservation. Columbia, Sanpoil, and Okanogan rivers all flow in deep canyons from 1,500 to 2,500 feet below the general level. Grand Coulee, a dry

[a] Calkins, F. C., Water-Sup. and Irr. Paper No. 118, U. S. Geol. Survey, 1905, pp. 45-49.

canyon about 500 feet deep, extending southwestward from the Columbia across the big-bend plateau is another remarkable feature which must be considered in any discussion of this region.

The Columbia and Sanpoil valleys, to an elevation of 1,500 feet above the water, are characterized by broad terraces of silt and gravel. The upper terrace is in most places well marked. South of the Columbia it extends for short distances up many of the small tributary canyons, which widen out into straths at this elevation. A very noticeable example of these straths is seen on the road from Wilbur to Clark, which follows a small canyon that at the level of this terrace widens out into an attractive little valley containing one or more farms. North of the Columbia the topography previous to the terracing was of an older type, and many of the upper terraces extend for several miles away from the river in the valleys of tributary streams that flow in deep canyons with silt and gravel walls. The lower terraces, although nearly as extensive as the upper, are more irregular and are not easily correlated with one another. Although they occur at various elevations most of them are between 20 and 300 feet above the river. Bench lands of this type, especially at the lower elevations, are in many places easily irrigated from small tributary streams. Such lands south of the Columbia are used almost exclusively for fruit culture and are valued at $40 to $400 an acre.

GEOLOGY.

GEOLOGIC FORMATIONS.

Nearly all the rocks north of the Columbia and in the bed of its canyon are schists or intrusives of various kinds, which probably range in age from lower Paleozoic to early Tertiary. They have not yet been studied in sufficient detail to differentiate the areas of the various types. South of the Columbia these crystalline rocks are buried beneath basalts and interbedded sediments of Miocene age, which have been described as the Yakima basalt.[a] Generally these basalts terminate at the south side of the Columbia gorge, though there are a few small areas within the Colville Reservation capped by them. East of the reservation the basalts extend a few miles north of Spokane River, where they overlap, the crystalline rocks thinning out at their northern edge. The sands, silts, and gravels forming the benches and terraces along Columbia and Sanpoil rivers constitute the youngest formations in the region. In general the upper terraces are composed of fine, light gray or brown silt and sand containing only a small percentage of gravel. As will be shown, they are indirectly the products of glaciation. The sediments of the lower benches contain more or less false-bedded gravel and sand and are river deposits

[a] Smith, G. O., Water-Sup. and Irr. Paper No. 55, U. S. Geol. Survey, 1901, pp. 15-17. Calkins, F. C., Water-Sup. and Irr. Paper No. 118, U. S. Geol. Survey, 1905, pp. 30-45.

of more recent origin. Near the west end of the reservation there are many erratic bowlders and other indications of a glacier which moved down the Okanogan Valley from the north and spread out over the big-bend plateau to the brink of the Grand Coulee.[a] The valley of the Okanogan and the plateau south of the Columbia at this point are said to be strewn with glacial drift. Small areas of bowlders, probably the terminal moraines of valley glaciers, are found in the Sanpoil Valley about 50 miles north of the Columbia and in the Columbia Valley a few miles north of the mouth of the Spokane.[b] In the latter locality the moraine appears to be older than the terraces by which it is apparently overlain.

GEOLOGIC HISTORY.

The geologic history of the development of these topographic forms is interesting and may be briefly summarized here. Previous to the middle of the Tertiary period the drainage of northern Washington was developed. Columbia, Sanpoil, and Okanogan rivers flowed southward across the big-bend country, converging at some point now buried beneath the basalts.[c] Then followed a period of volcanic disturbance; the earth's crust south of the Columbia was fissured and great volumes of lava poured out and spread in sheets over the surface, burying the old surface beneath thousands of feet of new rocks. The pre-Miocene valleys were filled, and the Columbia was diverted to a new channel around the northern edge of the lava field, intercepting the valleys of the Sanpoil and Okanogan as it does now. After the volcanic period the whole region was probably elevated and these rivers cut gorges nearly if not quite to the present depth. Later the Okanogan glacier completely dammed Columbia River, forming in its upper valley a lake that extended for many miles. The waters of this lake spilled southward along the east side of the Okanogan glacier, cutting the 500-foot gorge known as the Grand Coulee,[d] whose bed at its upper end is cut into the crystalline rocks below the basalts. It is estimated to be from 1,000 to 1,500 feet above the river and indicates approximately the depth of water before the lake disappeared.

While the glacier remained the lake thus formed was nearly filled with sediments, the remnants of which form the higher terraces and benches above described. The upper terrace of the Columbia is reported to be continuous with a stream terrace in the Grand Coulee. When the ice barrier disappeared, the river resumed its former course,

[a] Russell, I. C., Geological reconnaissance in central Washington: Bull. U. S. Geol. Survey No. 108, 1893, pp. 87-89. Smith, G. O., and Calkins, F. C., Bull. U. S. Geol. Survey No. 235, 1906, pp. 35-41. Salisbury, R. D., Am. Geologist, vol. 9, 1902, pp. 212-213.

[b] Salisbury, R. D., Glacial work in western mountains in 1901: Jour. Geol., vol. 9, 1901, pp. 718-731.

[c] Willis, Bailey, Changes in river courses in Washington Territory due to glaciation: Bull. U. S. Geol. Survey No. 40, 1887, pp. 7-8.

[d] Russell, I. C., Bull. U. S. Geol. Survey No. 108 1893, pp. 90-92.

and its subsequent work has been the removal of these sediments from its valley. New and lower flood plains have been formed at intervals during this restoration of the old channel, a fact which accounts to some extent for the irregularity of the lower benches.

All the terraces within 300 feet of the river level were formed since the disappearance of the greater part of the barrier and under nearly normal river conditions.

The upper terraces consist of only imperfectly stratified sands and silts. Coarse gravels are comparatively rare and no false bedding has been observed. The lower benches, on the other hand, are characterized by much false bedding. In many places they are composed of coarse gravels and sands and have all the characteristics of river deposits.

RELATION OF GOLD DEPOSITS TO TERRACES.

Where observed the placer gold along the Columbia is confined to the lower benches and river bars, a condition which may reasonably be expected if the sediments of the upper terraces are lake deposits, and those of the lower terraces have been worked over and concentrated by the river. Moreover, the later benches and the modern river bars are progressively richer in gold, since they are the product of repeated concentrations of the various upper terraces which have fallen into the river and been washed away.

The terraces on which deposits of placer gold occur are all within 200 feet of the level of the river. They are in the main covered with a sandy soil from a few inches to 12 feet or more thick, containing some disseminated gold, below which is a pay streak from 1 inch to 4 feet thick, consisting of sandy clay and gravel resting on a thin bed of clay. Below this pay streak there is generally barren sand, gravel, or in some places clay to the level of the river. It is reported that a second or a third lower pay streak occurs at a few places, but no attempts have been made to mine such deposits, and our investigations indicate that they invariably contain less gold than the upper placers. The pay streak is as a rule stained by oxide of iron and easily distinguished from the overlying slits by its color. The gold tenor varies from a fraction of a cent to a possible maximum of $1.50 per ton, the average being not more than 4 or 5 cents per cubic yard. These gold deposits were tested by carefully panning samples taken from prospect holes and such natural exposures as cut banks of streams and upturned tree roots. The colors of gold in each pan were counted, the number recorded, and specimens from the various localities weighed on an assayer's balance to determine their average value. To check these results 31 samples of pay dirt were collected and sent to the United States Geological Survey concentrating pavilion at Portland, Oreg., where they were tested by fire assay. In making the assays about five times the ordinary amount was taken for fusion and quantitative determinations were made where, by ordinary methods, nothing but traces could have been reported. The colors of gold were found to range in value from less than 0.0005 to 0.02 cent, the average being about 0.002 cent. Nearly all of this is flour rather than flake gold and although very fine it is usually not difficult to save in panning. Some of the colors which appear to be larger, however, are thin flakes and scales that are very hard to separate from the black sand.

There is a noticeable difference in the size of the colors at various points along the river, some of the bars being characterized by very fine gold, and that of others being comparatively coarse. Generally the colors of any particular bar or pay streak are nearly uniform in size and appearance, but there are a few notable exceptions to this rule, some of the localities affording coarse flakes as well as uniformly fine flour gold, seeming to indicate a local source of supply for part of the gold.

ASSOCIATED MINERALS.

The gold is associated with black sand containing a large amount of magnetite and somewhat smaller amounts of ilmenite, zircon, garnet, and other heavy minerals. Platinum probably also occurs in small quantities, though its presence was not detected in the field.

An average sample of sand was run over the Wetherill separator at the concentrating pavilion and its mineral constituents were determined as follows:

Mineralogical composition of average sand from Columbia River terraces.

Magnetite	0.3
Ilmenite	.1
Garnet	.1
Zircon	.1
Quartz	39.4
Others	60
	100

One large color of gold and 16 to 20 small colors of platinum.

The amount of black sand in the pay streaks is much greater than in this sample, in some places reaching 3 or 4 per cent.

TYPICAL LOCALITIES.

Although there is probably some gold in the sands of the river throughout its length, the gold-bearing terraces on either side, which are called bars, are not continuous. Those adjacent to the right bank that were examined are Nespelem Bar, at the mouth of Nespelem River; Hell Gate Bar, a few miles above the Sanpoil; Peach Bar, opposite Peach post-office; Sixmile and Ninemile bars, 6 and 9 miles respectively above Spokane River; Wilmot Bar, opposite

Jerome post-office; Rogers Bar, a few miles below Hunter; Blue and Turtle Rapids bars, about 5 miles above Hunter; Stranger Creek Bar, opposite Gifford; and a bar about 6 miles above Daisy. In the Sanpoil Valley there are no indications that placer gold has ever been produced or exists in commercial amounts except on one or two of its tributaries. The more important of the deposits named above will be described in detail as follows:

COLUMBIA VALLEY.

Nespelem Bar is a terrace half a mile wide, 100 feet above the Columbia at the mouth of the Nespelem, which flows across the bar in a narrow canyon. Two miles above its mouth the Nespelem is incised in an upper terrace more than 1,000 feet above the Columbia, to which it descends in a series of falls caused by outcropping crystalline rocks. The lower terrace has a nearly level surface and where cut by the canyons presents the following section:

Section of lower terrace on Columbia River at mouth of the Nespelem.

	Feet.
Sandy loam	8–15
Gravel	$\frac{1}{6}$– 1
Stratified clay, locally called soapstone	80

Although 320 acres of land situated here have been secured by patent for placer-mining purposes, gold was found at only one locality in a thin pay streak, consisting of iron-stained sandy clay resting on sand, somewhat above the general level and covering about 2 acres of ground. No gold was found by panning in any of the beds composing the foregoing section. Similar tests of the sands from the beds of gullies cutting through to the clay bed rock and of material from the bed of Nespelem River also gave negative results. It was estimated that there is no ground on this bar which can be expected to yield as much as 0.01 cent per cubic yard by placer-mining methods.

Hell Gate Bar, situated on the north side of Columbia River, between the mouth of the Sanpoil and Hell Gate Rapids, is a strip of land about 2 miles long and from 300 feet to half a mile wide. The placer gold is confined to a low bench, which is probably overflowed at times of extreme high water. Much of its surface is covered with river bowlders from a few inches to a foot in diameter, and the pay dirt is contained either in the crevices between these bowlders or in a well-defined pay streak consisting of iron-stained gravel from a few inches to a foot thick within 3 feet of the surface. There is little overburden and the gold-bearing layer is easily reached. The average value of this pay streak is estimated by panning to be 5 cents per cubic yard. The colors of gold are all fine, averaging not more than 0.00125 cent in value. A sample of the richest material found was tested at the concentrating pavilion in Portland, Oreg., showing approximately the same result as to gold tenor. It was estimated that on this bar there is a deposit of pay dirt 6 inches thick, from 100 to 600 yards wide, and 2 miles long, which will average between 1 and 5 cents per cubic yard. Some of the richest of this ground was taken up by Chinese, who attempted to work it mechanically with water pumped from Columbia River, but their efforts were abandoned several years ago for the reason, as reported, that wages could not be obtained. The Columbia at Hell Gate Rapids is obstructed by a ledge of rocks that crosses from north to south. This ledge has been worn down by the river, but has probably always presented an obstruction to the current. The concentration of the gold below the rapids is probably due in part to this obstruction, an eddy being formed here in which the fine gold settled from the swiftly moving currents.

Between Hell Gate and the mouth of the Spokane there is comparatively little level land adjoining the river on the Colville Reservation. All of it is comprised in a low bench at the mouth of White Stone Creek, containing something over 300 acres, a similar bench opposite Creston Ferry, and a bench and bar opposite the town of Peach. The White Stone lands are entirely embraced in Indian ranches and were not examined for evidences of placer gold. A portion of the bench at Creston Ferry has been worked by placer miners, but the old workings are now abandoned and were not tested. Opposite Peach there is a bench about 300 feet above Columbia River which extends upstream to the mouth of the Spokane. A number of placer-mining claims have been located on this terrace, and it was examined critically. Where undermined by the river it presents the following section:

Section on Columbia River opposite Peach.

	Feet.
Light-colored sandy loam	12
Sand and gravel	1–2
Sandy clay, above which there is water seepage	6
Open cross-bedded gravel, containing many basalt pebbles one-fourth inch to 2 inches in diameter	200

No colors of gold could be obtained by panning from any part of this section, either from the sandy loam at the top or the gravel layer above the clay seam.

Between Peach and the mouth of Spokane River there is a large island in Columbia River that is overflowed at extreme high water. The upper end of this island was formerly worked by Chinese, their excavations reaching a depth of 3 or 4 feet. No mining is in progress there at the present time, and a part of the island is under cultivation.

From a point 3 miles above the mouth of the Spokane old Chinese excavations and ditches occur at short intervals for about 6 miles to the mouth of Ninemile Creek. None of these old workings extended more than 100 yards from the river.

Three miles above the Spokane is a bench about 20 feet above the river that contains an accumulation of large angular bowlders having the appearance of a moraine. It is probably the deposit mentioned by Salisbury as the terminal moraine of the Columbia River glacier.[a] It extends along the river about one-half mile. The pay streak, formerly worked by Chinese, occupies the spaces between these bowlders, which probably served as riffles to concentrate the fine gold. Some virgin ground found under a stump in the old workings yielded a fair result from panning, the colors being of two types, large thin flakes averaging 0.01 cent in value and the ordinary flour gold of the river averaging not over 0.002 cent in value. A sample tested by fusion at the concentrating pavilion gave $1.60 per ton in gold, but owing to the prevalence of bowlders not included in the sample this result should naturally be reduced about one-half.

At the mouth of Sixmile Creek, a mile above the point just mentioned, the glacial bowlders are no longer to be seen and a section of the terrace deposit was found to be about as follows:

Section on Columbia River at mouth of Sixmile Creek.

	Feet.
Silt and gravel, containing some clay	2
Gravel and clay	$\frac{1}{12}$
Coarse open-textured gravel, pebbles mostly from older rocks and 4 inches or less in diameter	20

The pay streak here is confined to the upper 2 feet of the section and was found by panning to have a value of 8 cents per cubic yard. The gold obtained includes some large thin flakes averaging 0.01 cent in value and much fine flour gold. A sample tested by fusion at the concentrating pavilion yielded only 4 cents per ton. There is a pay streak 2 feet thick here, extending back from the river possibly 800 or 900 feet, which will yield from 4 to 8 cents per cubic yard.

Two miles farther up the river, near the mouth of Ninemile Creek, there are something over 300 acres of land in two benches, one about 30 and the other 100 feet above Columbia River. The section on the lower bench is approximately as follows:

Section of lower bench on Columbia River near Ninemile Creek.

	Feet.
Sandy silt, from a few inches to	7
Iron-stained sand, gravel, and clay (pay streak)	1
Open-textured gravel	20

Old Chinese workings extend about 200 feet back and three-fourths of a mile along the river. The limit of the workings back from the

[a] Salisbury, R. D., Jour. Geol., vol. 9, 1901, p. 722.

river was evidently determined in some places by the thickness of the overburden and in others by the thinning out of the pay streak. The gold contains some large flakes worth 0.02 cent and much fine flour gold, bringing the average down to 0.0067 cent. The pay streak probably averaged a little over 40 cents to the cubic yard. A sample tested by fire assay at the concentrating pavilion gave 16 cents per ton.

The upper terrace, 100 feet above the river, presents a somewhat similar section, comprising from 1 to 3 feet of iron-stained gravel, sand, and clay, resting on more than 90 feet of cross-bedded gravel and sand. Panning tests showed that the upper layer carries a small fraction of a cent in flour gold per cubic yard, while the gravel and sand below show no trace of gold.

Wilmot Bar is about 6 miles farther up the river, opposite Jerome post-office. As at Sixmile Bar, there are two terraces here—one 20 feet, the other about 100 feet above the river. The lower terrace is situated just below a series of rock ledges forming an obstruction to the current somewhat similar to that at Hell Gate and the concentration of gold on the bar is probably due in part to this cause. On the lower terrace there is a surficial deposit from 1 to 5 feet thick that contains flour gold and rests on open-textured gravel and sand. Panning tests indicate a possible value of 10 to 14 cents per cubic yard on the lower bench and a small fraction of a cent per cubic yard on the upper one.

Rogers Bar, on the west bank of the Columbia 2 miles below the town of Hunter, contains approximately 1,500 acres of nearly level land that lies from 20 to 100 feet above high water and extends for 3 miles along the river. It includes three distinct benches—one 30, another 75, and a third 100 feet above the river. Near the middle of the bar two men are still working with rockers on the river bank, following the edge of the water as it falls. They report that the best pay is found on bars exposed only at low water. Half a mile below their workings there is a low gravel bar that is scarcely above the level of the river at ordinary stages; this was nearly all worked over by Chinese. A miner working here reported that under favorable conditions he could make as high as $3 per day. Near the lower end of Rogers Bar is a large island in the river known as Hog Island. The channel between it and the mainland is dry at low water and its bed has all been worked by Chinese.

The section of the deposit forming the lower terrace at Rogers Bar is as follows:

Section of lower terrace on Columbia River at Rogers Bar.

	Feet.
Sandy silt	2–8
Gravel and clay (pay streak)	$\frac{1}{6}$–1
Open-textured cross-bedded sand and gravel	20

The section in the next higher bench is similar except that the underlying gravel contains more sand and there is a greater thickness exposed. On the lower bench flour gold to the value of 1 to 50 cents per cubic yard was found in the pay streak, and a much smaller amount disseminated through the overburden. Tests by fusion at the concentrating plant gave somewhat higher values and would seem to indicate that there is a considerable amount of finer gold which could not be saved by ordinary panning. In some instances traces of platinum were reported by the assayer, but the amount was not determined. No gold was found on the uppermost terrace, which as noted lies 100 feet above the river. The bars below the level of ordinary high water carry values in gold somewhat higher than those of the terraces, the indicated value being more than 30 cents per cubic yard. The colors of gold at Rogers Bar have an average value of about 0.00125 cent and the samples contained at least one color worth 0.01 cent.

Blue Bar, situated on the right bank of Columbia River, about 4 miles above Hunter, consists of a terrace from 100 to 1,000 feet wide and 20 feet above the river. Opposite the bar in the river lies Blue Bar Island, with an area of about 100 acres. Mining was done by Chinese at the upper end of this island, as well as at the edge of the terrace, to which water was brought in a ditch from a small stream known as Stray Dog Creek. The section of the deposit making up the terrace at Blue Bar is approximately as follows:

Section on Columbia River at Blue Bar.

	Feet.
Sandy loam	$\frac{1}{2}$–7
Iron-stained gravel, containing some clay (pay streak)	$\frac{1}{6}$–$\frac{1}{2}$
Open-textured gravel and sand	15

Nearly all the gold is confined to the pay streak, though scattering colors can be found in the overburden. The results of panning this pay streak indicate values ranging from less than a cent to 6 cents per cubic yard. Samples tested by fusion at the concentrating pavilion yielded from 2 to 41 cents per ton.

Two miles above Blue Bar, near Turtle Rapids, a bench 60 feet above high water extends along the river for several miles. Old Chinese workings here expose a nearly barren layer of sandy silt several feet thick, resting on a pay streak a few inches thick, consisting of gravel and clay, below which is open-textured gravel and sand. These old workings indicate that the pay streak was followed back from the river bank until the overburden became too thick to permit further mining in that direction. Some of the original pay dirt was panned, indicating an approximate value of 30 cents per cubic yard, one pan containing upward of 300 fine colors of gold, the average value of which was 0.00143 cent.

At the upper end of these old Chinese workings an attempt was made last summer to hydraulic this deposit, a small stream of water under a 30-foot head being used. The pay streak was estimated from panning to contain about 9 cents per cubic yard. Two fusions were made of the sample sent to the concentrating pavilion, giving from 1 cent to 13 cents per ton. Half a mile above this point a pay streak 2 feet thick lies on the surface of the bench, with no overburden. It extends back from the river 300 feet to the foot of the escarpment from a higher bench. Panning here indicates that this pay streak has a placer value as high as 9.5 cents per cubic yard. Two fusions were made of the sample taken from this place, one showing no trace and the other 15.5 cents per ton.

Attempts at mining have been made on the lower terrace at intervals above this point for several miles, but the workings are now abandoned. Mining by hydraulicking was in progress on a bench at the mouth of Stranger Creek, which enters the Columbia opposite Gifford. The section exposed here is as follows:

Section on Columbia River at mouth of Stranger Creek.

	Feet.
Sandy soil	7
Pay dirt, consisting of clay and gravel	1–3
Loose open-textured gravel and sand	20

The pay streak was tested by panning at several places and is estimated to contain from 40 cents per cubic yard at the richest spot to 5½ cents at the poorest. The sandy silt above the pay streak carries a small amount of gold, which is concentrated with that from the pay streak in hydraulicking. Prospect holes at other places on this bench seem to indicate that the pay streak is not of very great extent. A sample cut from the top of the overburden across the pay streak at its thickest part, thus including pay streak and overburden, was tested by fusion at the concentrating pavilion and gave results varying from 14 to 32 cents per ton. This placer is located on the bank of the river just below a ledge of rock which must have always acted as an obstruction to the current, and the rich deposit here bears the same relation to this obstruction as do the deposits at Hell Gate and Wilmot Bar to similar ledges.

For several miles above the Stranger Creek placer a terrace at the same level that extends back from the river a distance of 800 or 900 feet has been located for placer-mining purposes. The sections exposed in the river bank and in prospect holes indicate a deposit of gravelly soil about 2 feet thick, resting on an iron-stained pay streak, below which there is open-textured gravel. Panning tests of these deposits indicate a possible value of a fraction of a cent per cubic yard, to a depth of 2½ feet, but samples tested by fusion at the concentrating pavilion showed no trace of gold. Back of the lower terrace there is a higher one about 300 feet above the river, containing 300 or 400 acres of land that has also been included in placer claims. These lands, as far as could be ascertained, have a light sandy soil to a depth of 1 or 2 feet, underlain by tough clay to an unknown depth. No traces of gold could be found in either the surface soil or the clay.

Benches lying 20 to 30 feet above the river level and similar to those which have been described extend along the left bank from this point nearly to Kettle Falls. One of these, 2 miles above Daisy, presents the following section in the cut bank of the river:

Section on Columbia River 2 miles above Daisy.

	Feet.
Soil	1
Iron-stained pay streak	½
Open-textured gravel and sand	18

Fragments of shells of river mollusks were found in the silt just below the pay streak. A sample from the pay streak was panned, showing a value of 2 or 3 cents to the cubic yard, but the assays made at the concentrating pavilion showed only a trace of gold.

A low bar in the river several miles above Daisy, formerly known as China Bar and reported to have been worked out by the Chinese, was also tested and the upper layer of sand and gravel yielded about the same result—2 or 3 cents to the cubic yard.

SANPOIL VALLEY.

The Sanpoil Valley is disproportionately large for the stream which it contains. Its walls are terraced to almost the same elevations as those of the Columbia Valley and it was probably occupied by an arm of the same lake as filled the Columbia. It also resembles the Columbia in that the lower terraces and benches are more irregular than the upper ones. Although colors of gold were found at intervals along this river they are not as uniformly distributed as along the Columbia and are not concentrated in pay streaks to the same extent. A great many placer claims have been located near the mouth of West Fork, in the vicinity of Alkire post-office. Tests with the gold pan indicated a value of about 4 cents per cubic yard in one or two small spots, outside of which colors of gold were very rarely found. These colors are rougher than those along the Columbia and average 0.0055 cent in value. A sample representing thirteen prospect holes, all of which were well located to find placer gold if present, was tested by fusion at the concentrating pavilion and showed no trace of gold. About 3 miles above its mouth West Fork of the Sanpoil receives a tributary called Gold Creek, and several miles up the latter Strawberry Creek enters. Reports of miners indicate fair prospects of gold on each of these latter streams, and an imperfect examination of them confirms the reports. The deposits along Strawberry Creek are said to be of the normal creek-placer type. They are confined to the bed and the immediate flood plain of the stream, and the gold is of local origin. Below Alkire the sands of the Sanpoil Valley were tested at a number of places, almost invariably with negative results, though a few colors of gold were obtained near Keller. No deposits of gold-bearing gravel that will justify the expectation of successful development occur along Sanpoil River at any point except those noted on West Fork.

ORIGIN OF THE GOLD.

The ultimate source of the Columbia River gold is to be found in the areas of crystalline and metamorphic rocks to the north and east, which are known to contain gold-bearing quartz veins, as well as other ore bodies of various kinds containing gold. Millions of tons of such rocks were washed away in the formation of the river valley, and the deposits with which the valley was filled during the glacial period represent many millions more, the gold content of which has been concentrated in river bars. Much of this gold has doubtless been carried many miles, but that some of it is of comparatively local origin is indicated by the coarse flake gold found on some of the bars. Somewhat coarser and rougher colors of gold were obtained from the bed of a small creek several miles from the Columbia. It is probable that there are many such tributary streams in which colors of gold can be found which have added small amounts to the gold deposits of the river.

METHODS OF MINING.

The mining and collecting of finely divided gold like that along the Columbia is inevitably more difficult and requires greater care and skill than ordinary placer mining. The appliances which have been used are rather simple forms of rocker or sluice box equipped with blanket, carpet, or burlap riffles. Neither quicksilver nor copper plates are used in the boxes. In sluicing, the material is invariably passed over some form of grizzly which screens out the finer part and drops it to an undercurrent or spreads it over tables where the gold is collected. The Chinese probably ground sluiced before shoveling the pay dirt into the boxes. In two places where white men were mining last summer the whole deposit above the pay streak was hydraulicked and washed into the sluice with water under a small head from a canvas hose. One of the principal difficulties in mining this gold is encountered at the clean up. The gold is associated with such great quantities of black sand that it is almost impossible to separate it. The usual method of collecting the gold with quicksilver is laborious and expensive, often fails to extract much of the gold, and utterly fails to collect platinum if it is present. Experiments made at the concentrating pavilion at Portland have demonstrated that this separation can be accomplished economically by means of a Wilfley concentrator, but even by this means the expense of mining would probably not be greatly reduced.

CONCLUSIONS REGARDING COLUMBIA RIVER GOLD.

Nearly all the sands in the bed of Columbia River and on the adjoining terraces and benches throughout the region covered by this examination carry some fine gold. The relative amounts have not been accurately determined, though the statements of miners and prospectors indicate that the low bars in the river bed contain more gold than the deposits on the benches.

The average width of the river is about 1,500 feet, and it is probable that a considerable part of its bed from one side to the other is covered by sands and gravels containing some gold. The gold-bearing terraces are not continuous on either side, being absent for long stretches, and it may be safely estimated that if distributed so as to be continuous they would make a strip of land not exceeding 300 feet on each side of the river.

Many of the richer spots were discovered and worked out by Chinese, and there is no record of the amount of gold they obtained. Moreover, the observations described in this report were not sufficient to justify a close estimate of the amount of gold remaining. It would seem a liberal estimate, however, to put the average width of the gold-bearing areas, including the river bed and benches, at 2,400 feet, the thickness of the gold-bearing deposit at 6 feet, and the amount of placer gold originally contained within such limits at 1 cent per cubic yard. On these terms the total amount of gold contained in the river bed and adjacent benches did not exceed $28,000 per linear mile, and the total amount in the 90 miles between Kettle Falls and Nespelem did not exceed $2,500,000.

This gold is not uniformly distributed, but in very small areas is concentrated enough to justify mining, especially where rich deposits occur in the bed of the Columbia, since the comparatively cheap process of dredging is here available. The bench lands, however, are not adapted to any relatively inexpensive process of mining. Hydraulicking on a large scale is ruled out by the absence of bed rock and the scarcity of water at sufficient elevation; dredging, by the height of these deposits above the river and the impossibility of floating the machinery over them. Moreover, the possible profits from mining the bench lands would undoubtedly be less than the value of these lands for agricultural purposes.

GOLD DEVELOPMENTS IN CENTRAL UINTA COUNTY, WYO., AND AT OTHER POINTS ON SNAKE RIVER.

By Alfred R. Schultz.

INTRODUCTION.

The present paper comprises a brief preliminary statement of some of the results obtained from surveys made by E. E. Smith, B. A. Iverson, H. C. Schleuter, and the writer during the summer of 1906 in Tps. 23 to 39 N., Rs. 113 to 117 W., inclusive, Uinta County, Wyo.

The examination of this region was made primarily for the purpose of determining the locality of the various coal and oil beds that occur in Uinta County and to trace northward the coal formations mapped by A. C. Veatch and the writer in southern Uinta County during the summer of 1905. In carrying out this plan the surveys were carefully tied to the land corners, and geologic and sketch topographic maps were prepared on a scale of 2 inches to the mile, with a contour interval of 100 feet. These separate field sheets, covering an area a little larger than that included in the above-mentioned townships and ranges, are now being compiled into a single base map, on a scale of 1 inch to the mile, which will show all the streams, land corners, houses, fences, roads, and trails found in this examination and will be used as a base for the several maps that will accompany the complete report now in preparation. These maps will show the areal and structural geology, the location and depth of the coal beds, the location of the oil-bearing shales, the occurrence of iron and gold, and the regions where they may be found. It is the purpose in this preliminary report to give a short description of the occurrence of gold in central Uinta County and point out to what extent development has been carried. The detailed report on this area, to which the reader is referred for further information, will probably be ready for distribution during the spring of 1908.

SURFACE FEATURES.

This area has an elevation ranging from 5,700 feet on Snake River to 11,500 feet on the crest of the mountain ranges. In the vicinity of

Sheep Creek, a tributary to John Days River, where the most rugged topography was encountered, there is a change in the elevation of 3,000 feet in less than half a mile. The area is traversed from west of north to east of south by two parallel mountain ranges—Salt River Range and Wyoming Range—and is bounded on the northeast by the Gros Ventre Mountains, which extend in an east-southeast and west-northwest direction. Near the south end of the area the Salt River and Wyoming ranges become lower, passing into Absaroka Ridge and Meridian Fold, respectively, and they finally lose their topographic importance south of the area, where the rocks of which they are composed are deeply buried by Tertiary deposits. There are numerous minor ridges and folds, in general more or less parallel to the main ridges, the most important being the Hoback Range, which connects the Wyoming Range and the Gros Ventre Mountains. To the east of the Wyoming Range is the great plain-like basin of Green River, whose mean elevation is about 7,500 feet. The entire area, except a narrow strip along the eastern margin, is a rugged succession of mountain peaks and ridges cut by numerous gorges and canyons whose walls often are in places nearly perpendicular. Many of the hills, valleys, and slopes are well timbered with pine, fir, and spruce.

The drainage belongs to three great systems—Snake River, whose waters flow into the Pacific; Green River, whose waters flow into the Gulf of California; and Bear River, whose waters enter the Great Basin. The greater part of the drainage area is almost equally divided between Snake and Green rivers, with a margin in favor of Snake River, only a small area in the southwestern portion being drained by the tributaries of Bear River.

STRATIGRAPHY.

The survey of last summer was carried on with special reference to coal, nearly all of the work being restricted to the coal-bearing formations. Some time was devoted to the formations contiguous to the coal-bearing rocks, and sufficient information regarding their age was obtained to correlate them with similar beds in other parts of the country. The fossils collected were studied by Dr. T. W. Stanton and indicate that the formations studied and mapped in the field (Pl. I) are of Jurassic age and form the upper portion of the Jurassic in this area.[a]

[a] For the geologic time values of the rocks other than those mapped in Pl. I see Veatch, A. C., Coal and oil in southern Uinta County, Wyo.: Bull. U. S. Geol. Survey No. 285, 1906, pp. 332-334; or the report by the writer on coal in central Uinta County, Wyo., now in preparation.

STRUCTURE.

The main disturbance in this area occurred near the close of the Cretaceous period, during the interval marked by the unconformity between the lower Laramie and Evanston[a] formations. A second and minor disturbance occurred after the deposition of the Evanston beds. The movement during this disturbance was for the most part along several of the old lines of weakness, faulting and tilting the younger beds so that they dip in some places from 40° to 50° and in an opposite direction to the older underlying beds. A third disturbance may have occurred between the deposition of Jurassic and the Bear River. There are some evidences indicating that the lower Cretaceous is entirely wanting in this area, but this has not been positively proved. There was, however, at this time no great disturbance associated with folding and faulting, for throughout the area the Bear River formation is apparently conformable upon the known Jurassic beds.

The principal structural features of this region are parallel to each other and have a north-south trend with a slight westward deflection, which increases toward the north. These are the direct northward continuation of the faults and folds observed in the northern portion of the area mapped in southern Uinta County during the summer of 1905. The important structural features at the south end of the area here considered, named in order from east to west, are (1) a rather regular anticline, with two or more secondary folds—the Meridian anticline; (2) a rather regular syncline, in places slightly overturned—the Lazeart syncline; (3) a large and persistent faulted anticline, with a downthrow to the east and a displacement of 14,000 to 15,000 feet; and (4) a broad syncline—the Fossil syncline—which lies for the most part west of this area. To the north the structural conditions become more complicated. Several new folds and faults occur, and the entire region is more disturbed, giving rise to the Hoback, Wyoming, and Salt River ranges. The important structural features at the north end of the area, named in order from east to west, are (1) a rather irregular, complex anticlinorium which gives rise to the Hoback Range and passes toward the south into a regular anticline; (2) a synclinorium, the south end of which is a monosyncline, with beds dipping from 25° to 45° W.; (3) a faulted anticline, with a downthrow to the east and a displacement of about 15,000 feet; (4) the northward continuation of the Lazeart syncline, which develops a secondary fold in the vicinity of Snake River; (5) the northward con-

[a] Evanston as here used is the same as the Evanston formation in southwestern Uinta County. (See contributions to Economic Geology, 1905: Bull. U. S. Geol. Survey No. 285, 1906, pp. 332, 335.) C. A. White (Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, pp. 240-241) used the name "Evanston coal series" in referring to the coal-bearing beds of Almy below the Wasatch and above the Bear River. Lesquereux (Sixth Ann. Rept. Geol. Survey Terr., 1873, p. 409) used the term "Evanston deposits."

tinuation of the Absaroka fault, which here lies along the east base of the Salt River Range. The displacement along this fault is about the same as in the south end of this area. The Salt River Range has been uplifted and its component rocks thrown into the sharpest folds. As most of the range lies west of this area, no detailed sections were made across it, but very probably the same type of structure exists here as in the Hoback Range. The faulted anticline (3) gives rise to the Wyoming Range, and the fault extends approximately along the eastern base of the range in much the same manner as the Absaroka fault along the Salt River Range. These two faults are connected by a cross fault in which the downthrow is on the south, with a displacement of about 5,000 feet. Near the south end of the Wyoming Range two or more secondary folds are developed.

MINING DEVELOPMENTS.

GOLD IN THE ROCKS.

The gold that has thus far been reported lies in the northern third of the area above described. The reported gold on the east side of the Wyoming Range occurs in sedimentary rocks of Jurassic age. The only prospecting that has been done is in the vicinity of Horse Creek, in T. 34 N., R. 114 and 115 W. Numerous claims have been staked out along this creek, but thus far practically no development work has been carried on. A few shallow pits have been opened on both sides of the creek. Some of these pits were visited by E. E. Smith and the writer last summer, but no indications of gold were visible. It is reported locally by persons who are interested in the claims that several assays of the rock on Horse Creek show high values in gold and silver. Among the best was a sample taken from the ledge on Wesley Vickery's claim, where the rock is said to assay as high as $66 per ton in gold and a maximum of about $18 per ton in silver. This claim was not visited nor any of the rock samples seen by members of this party while on Horse Creek, but the sample sent by Mr. Vickery from his 40-foot tunnel looks promising, and if much such came from this vicinity it would certainly justify further development. The Jurassic rocks here consist of bluish-gray shales and limestones, with some gray and yellow sandstone interbedded with dark-gray shales. They lie on the west side of the anticlinal fold and the beds dip toward the west at angles of 30° to 45°. On the north side of Horse Creek the strike turns abruptly and continues N. 40° W. approximately along the trend of the stream which here follows the outcrop of the Benton shale. In this locality the Jurassic beds are slightly brecciated and contain numerous small seams of calcite. Some of the rock shows considerable iron pyrite, and in many places iron stains are associated with the calcite cavities. The claims are by no means restricted to the Jurassic outcrop, but cover the Bear River and Benton shale outcrop as well. In neither of these sedimentary beds was there any evidence of gold deposits. In several localities, however (as reported), fine gold particles or flakes have been found in the Benton shale. Wherever found, the flakes are disseminated through the shale and occur in very small quantities. It is said that two assays have been made of these shales and that traces of gold were found in both samples.

PLACER DEPOSITS.

OCCURRENCE AND CHARACTERISTICS.

Gold was observed at various points on Snake River and its tributaries. It occurs either in the gravels forming the terraces along the streams or in the deposits of bowlders, gravel, and sand filling the channels or forming the beds of the streams.

Interesting examples of terrace formation are seen on both sides of Snake and Hoback rivers at points where the valley expansions permit their preservation. At several places along Snake River above the canyon the terrace declivity shows a thickness of 10 to 15 feet of horizontal stratified pebbles and bowlders at elevations ranging from 50 to 100 feet above the river bed, and some of the highest terraces are as much as 200 feet above the river. The terraces slope gently toward the center of the valley, and their slopes are strewn with water-worn rock fragments similar to the material found in the river bed. The material consists chiefly of quartz, with some granites, schists, shales, slate, and sandstones, and here and there some volcanic material, which no doubt is derived from the upper Snake in the vicinity of the Yellowstone National Park. Snake River, between the canyon and the mouth of Hoback River, occupies in many places a wide shoal bed and in autumn exposes extensive bars of shingle and cobblestone, among which the river winds in several channels. Many of the terraces along Hoback River, below the canyon, extend back one-quarter to one-half mile from the present river channel, whose bed is paved with water-worn pebbles similar to the material found in the Snake River channel, the granites and schists coming from the Gros Ventre Mountains several miles to the northeast. Near the lower end of Hoback River, where the stream cuts across two anticlines of low dip and the eroded sandstones and shales produce ripples in the stream, several flakes or scales of gold were found in the sands accumulated near the water's edge. Whether these gold flakes occur in the gravels farther up Fall River above the canyon and along its tributaries heading in the Gros Ventre Mountains was not determined. Numerous small streams that emerge from the mountains can be utilized in sluicing operations or for generating power to run a concentrating plant.

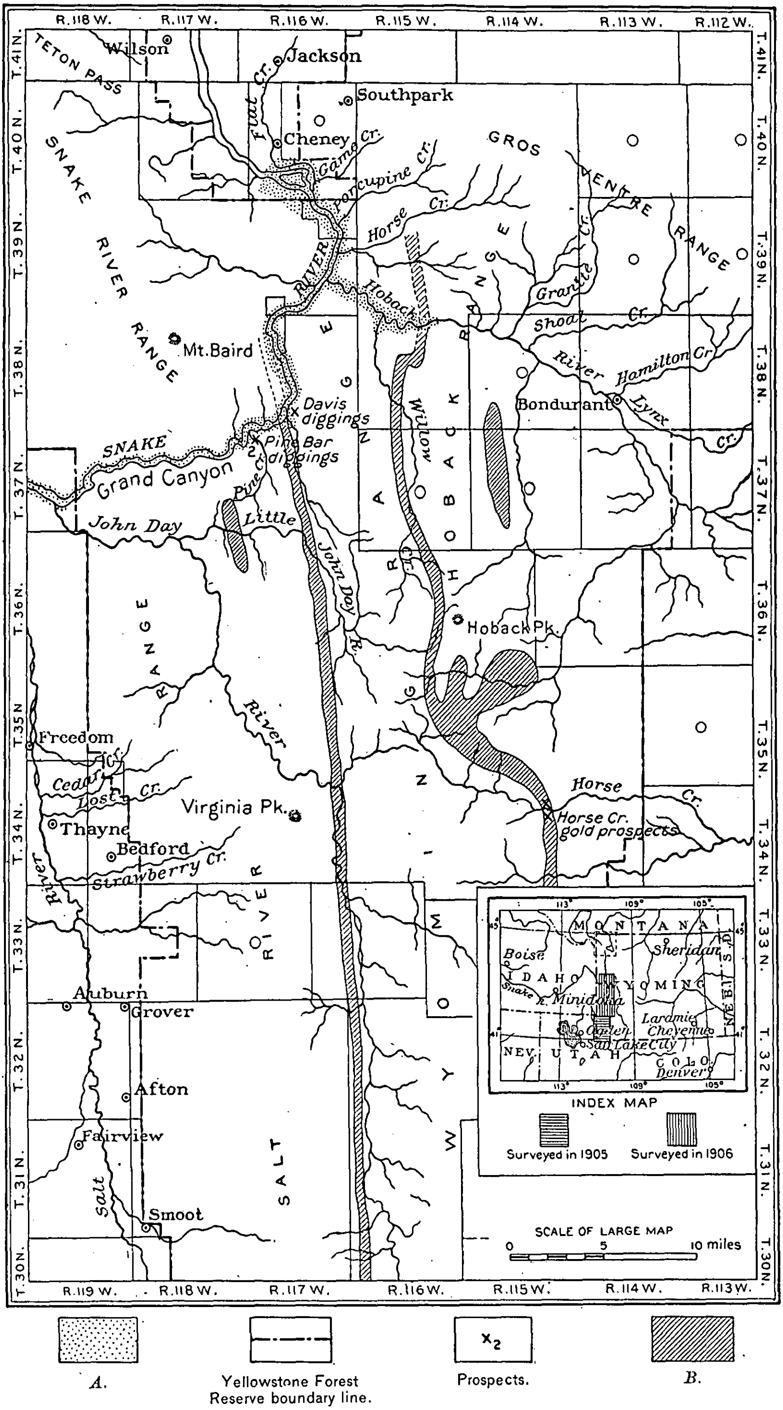
That these upper Snake River gravels contain gold has been known for some time, and as early as 1862 prospectors were trying to extract the shining colors or gold flakes from the coarse gravels and fine sand along the stream. Some of the first workings on the Snake above the Grand Canyon were in Jackson Hole, north of Gros Ventre River. These early discoveries are described by Frank H. Bradley,[a] in his report on the Snake River expedition in 1872, as follows:

A considerable excitement was stirred up, a few years since, by reported discoveries of placer gold in large quantities on the upper Snake, and many prospectors visited this region. A small hydraulic operation was undertaken near this point; but the gold was too fine and in too small quantities to pay, and the whole region was entirely abandoned after a few months. The coarse gold, found on the lower part of the Snake, appears to have entered the river below the canyon, which is still to the southward of us.

In 1878 Orestes St. John[b] found on the terraced interval along Snake River in the vicinity of Bailey Creek indications of old placer workings that had been opened in 1870 by a party of miners associated with Jeff Stantiford. The enterprise was, however, interfered with by the Indians and organized mining operations were discontinued. In recent years considerable prospecting has been done along Snake and Hoback rivers, but very little real development work has been carried on. Claims have been located and staked out on the gravel terraces along the greater portion of Snake River and along Hoback River below its canyon, but only enough work has been done to hold the claims.

The placer-gold deposits along Snake River may be classed as stream placers and bench placers. The stream placers consist of the deposits of bowlders, gravels, and sand that form bars, banks, fills, and shoals in or adjacent to the streams, filling the channels and forming the stream beds. Many of the bars, banks, and fills are only temporary and vary more or less during every heavy storm. The bench placers are located in the old stream deposits, which are at present represented by the terrace remnants that mark the former level of the stream at a considerable elevation above the present river bed. None of the stream-placer deposits within the area are at present worked and only in two localities are the bench placers mined systematically. These are on Andrew J. Davis's claim on the east bank of the river, north of the mouth of Bailey Creek, and on Hoffer & Rosencrans's claim at Pine Bar, on the south side of Snake River at the mouth of Pine Creek, 1½ miles below the mouth of Bailey Creek. (See map, Pl. I.)

[a] Sixth Ann. Rept. U. S. Geol. Survey Terr., 1873, p. 266.
[b] Twelfth Ann. Rept. U. S. Geol. and Geog. Survey Terr., pt. 1, 1883, p. 196.



MAP SHOWING LOCATION OF SNAKE RIVER GOLD PLACERS IN A PORTION OF UINTA COUNTY, WYO.

A, Gravels known to be gold bearing. Some auriferous gravels extend farther up Snake River than here shown, but their distribution north of T. 39 N. is unknown. Similar gravels extend farther up Hoback River and its northern tributaries, but they are not known to be auriferous. *B*, Jurassic rock similar to the beds on Horse Creek, in T. 34 N., Rs. 114 and 115 W., in which gold was reported to have been found.

DAVIS DIGGINGS.

The placer workings on the Davis claim are on a low terrace along the east side of Snake River, extending from the mouth of Bailey Creek about half a mile to the north. They are in the vicinity of those opened by Stantiford in 1870. There are two distinct terraces here, and Mr. Davis is at present working parts of both. The fine flour or flake gold of a high degree of fineness occurs all through the gravel, but is much more abundant in some streaks than in others. One of the main pay streaks near the Snake River channel is from 4 to 6 inches thick and is overlain by 4 to 6 feet of gravel that contains much lower values in gold and is in turn overlain by a nearly barren gravel bed 4 to 5 feet thick that extends to the surface. The rich pay streak, from 8 to 10 feet below the surface, makes it profitable to work the entire bank. On working back into the bank away from the river, these seams are found to rise and a new pay streak about 6 feet thick and richer than the other one is encountered. The new pay streak drops slightly farther east and probably represents the deposits of an older channel of Snake River. The different placer mines and even parts of the same terrace vary considerably in the character of the deposits and arrangement of their beds.

Water for hydraulicking is brought in a ditch from a point some distance up Bailey Creek and used to break down the gravels, wash out the gold and fine particles, and sluice through the flume. Sometimes the gravel is shoveled into the sluice boxes and in both methods the large bowlders are piled up in rows between the boxes so as to retain as much of the grade as possible and still work the lower pay streaks. The fine material drops through a series of steel-punched screens near the lower end of the sluice and is diverted at right angles through a distributing box onto a series of inclined tables about 4 feet wide and several feet long, covered with canvas or burlap, on which the gold and concentrates readily settle. About four-fifths of the gold and heavy concentrates are caught on the first few feet of the tables and are swept into a tray every few hours by diverting the pulp and turning on clear water. In order to catch the gold that may have escaped from the tables several boxes are placed in the path of the water between the tables and the river and the material collected in these boxes is run over the tables a second time. The concentrates and gold are stored until a sufficient batch is accumulated and are then placed in a small churn, or grinding pan, which is run by water power from the sluice box. Quicksilver and warm water are added to the concentrates and the machine set in motion. The gold amalgamates readily after a few hours of grinding and is then run into bars or sheets ready for the market. The gravels at these terraces, as shown by the workings for the last few years, run from 3 cents to $3 per cubic yard. Pay streaks that run $2 to $3 per cubic yard are very thin and rare. The average run of the gravels, all the pay streaks, and the comparatively barren gravels being considered together, is between 7 and 10 cents per cubic yard. Only one piece of coarse gold has thus far been found at this place. The nugget was said to be about half the size of a tenpenny nail.

During the last year several hundred dollars worth of gold was taken from this area. In Mineral Resources of the United States for 1905, page 341, the following statement is made under the heading of Uinta County, Wyo.: "A little placer gold is reported from Jackson Hole near the western boundary line of the State."

Four samples of black-sand concentrates were taken from Davis diggings and David T. Day in his report on these samples makes the following statement:

These samples consist largely of magnetite, No. 1, apparently not much concentrated, containing 1 ounce of magnetite to 4½ ounces of the original material. They are all rich in gold but contain no platinum. The percentage of gold was not determined, but they will all range from $30 to $100 per ton and probably more. This gold could easily be extracted by means of shaking tables of the Pinder, Wilfley, Woodbury, or Deister type, but it is doubtful whether very much can be taken out by other means, certainly not by sluice boxes, as you have probably already found.

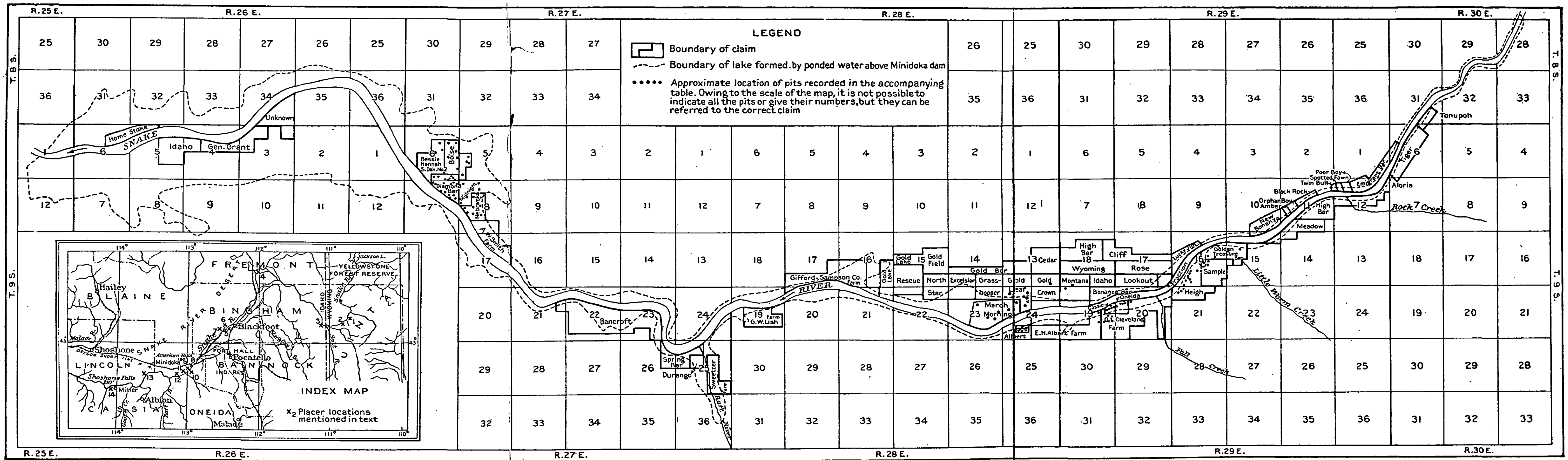
Doctor Day in his work on the investigation of black sands from placer mines[a] found that the effective operation of these concentrate tables is comparatively independent of the fineness of the gold. In many sands, gold as fine as 200 mesh is readily saved on the tables, frequently from 95 to 98 per cent of the total assayed value. A brief description of these tables and additional data on the black sands of the Pacific slope by David T. Day and R. H. Richards may be found in Mineral Resources of the United States for 1905, pp. 1175–1258.

PINE BAR DIGGINGS.

The terrace at the mouth of Pine Creek, on the south side of Snake River, has been worked during the last two years by Ivan L. Hoffer and L. M. Rosencrans. The methods employed are much the same as those above described for the Davis diggings. The water for hydraulicking is brought from a point some distance up Pine Creek in a ditch across the bench and used wherever it may be desired. The terrace or old bar at this point is 1 mile long and one-twelfth to one-eighth mile wide. The terrace for the most part is from 40 to 50 feet above the water level in Snake River.

Mr. Hoffer informed the writer that on this bar there is about 8 feet of overlying gravel that contains about 15 very fine colors per cubic foot, followed by 32 feet of gold-bearing gravel to water level without striking bed rock. So far only the upper 12 feet of this gravel, which is supposed to be better than that lower down, has been worked.

[a] Bull. No. 285, U. S. Geol. Survey, 1906, p. 164.



MAP SHOWING LOCATION OF PLACER CLAIMS ALONG SNAKE RIVER IN THE VICINITY OF MINIDOKA, IDAHO.

Base taken from United States Reclamation Service index map of Minidoka project.

The following figures furnished by Mr. Hoffer give the run of gold in colors for the first 12 feet of gravels as tested in two different places:

Colors of gold in upper gravel at Pine Bar diggings.

Depth in feet.	Colors per cubic foot.	
	A.	B.
1	7,200	6,300
2	23,400	3,600
3	8,100	16,200
4	106,200	11,700
5	8,100	11,700
6	22,500	4,500
7	3,600	5,400
8	17,100	900
	196,200	60,300

The tests were made on one-thirtieth cubic foot of gravel carefully measured and the results per cubic foot were obtained by multiplying these values by 30. About 1,000 to 1,200 colors make 1 cent value. Thus it will be observed that this 8 feet of gravel, both tests being averaged, prospects from 12 to 14 cents per cubic yard. Including the upper 8 feet, the value for 16-foot depth averages about 7 cents per cubic yard. Working to a depth of 20 feet or more should slightly raise this value. In a few places small streaks running up to $2 per cubic yard have been cut. Most of these streaks occur on top of the gold gravels immediately below the overlying 8 feet of comparatively barren material.

OTHER WORKINGS ALONG SNAKE RIVER.

Ivan L. Hoffer, who is fairly well acquainted with the placers of upper Snake River from Milner, Idaho, to the head of the river, states that the gold is much the same in character throughout the length of the stream, being a flour gold of a high degree of fineness. The placer miner usually recognizes two kinds of this gold—the free flakes and the coated. The different placers, however, show great variation in character of the deposits and distribution of the pay streaks. The locations of a number of placer workings along Snake River between the Davis diggings and Milner, Idaho, are indicated on the index map in Pl. II by numbers corresponding to those in the following notes, which were furnished by Mr. Hoffer:

1. Davis diggings, described above.
2. Pine Bar diggings, described above.
3. McCoy Creek. The bars of Snake River opposite the mouth of this creek have been worked some, but at present are idle. At the head of the creek, however, are large hydraulic placers that make a good clean up each year. It is claimed that they have enough ground to last a good many years at their present rate of working.
4. Market Lake. This neighborhood has been the scene of a number of small placer excitements in the past, but it is not known whether any work is being done here at present. Some dirt running as high as $7 per cubic yard has been taken out of the placers at this point but the rich pay streaks were very small in extent. Between the mouth of McCoy Creek and Market Lake the river is apparently barren.

5. Four miles below Blackfoot, Idaho, is the most extensive bar worked for placer mining on upper Snake River. It is owned by J. G. Walsh and is worked by leasers, two parties operating each year. A well-equipped dredge is usually run in the river at this point, but was not used last season.

6. During last season this placer was operated by Mr. Cole, but with what success has not been learned.

7. Not working at present. Owned by a Portland company that has considerable machinery and a small dredge on the ground.

8. I. L. Hoffer property. Assessment work only has been done at this point.

9. Franklin mine, one of the best known on Snake River, owned by Mary Franklin and Campbell & Stebbin. Reported yield, $56,000. This claim consists of separate holdings.

10. Sorenson mine, owned by Julius Sorenson, of Neeley, Idaho, and worked by a company represented by Theodore Lindsley, of Neeley. This is the best mine on upper Snake River, having richer paid dirt than any other mine worked.

11. I. L. Hoffer claim, practically worked out. Some dirt running as high as $100 per cubic yard was taken out at this point.

12. Worked by Dunn & Hand. The old style of placer workings will in time be crowded out here on account of the backwater from the Minidoka dam but dredging will no doubt be done.

13. A few miles below the Minidoka dam, E. A. Keats owns 160 acres on which he has done some rocker work for nine or ten years. Before beginning sluicing operations he is waiting for water from the Government ditch. A few miles below this point, opposite Peterson's ranch, is a bar on which some work is being done by Frank Eblett. This is the last of the workings above Milner, Idaho, as the backwater of the Milner dam has driven out those operating on Snake River between this place and Milner.

14. I. L. Hoffer claim; worked out.

Robert N. Bell, State inspector of mines, Boise, Idaho, states that in southern Idaho the counties bordering Snake River annually report to the United States assay office at Boise small shipments of gold derived from sluicing operations along the lower bars that border the stream for miles. These small operators are satisfied with $2 to $4 per day per man. During the summer they pick a favorable place along the first terrace that rises 10 to 20 feet above high-water mark and affords a dump. They then build what is locally called a "machine," consisting of about 30 feet of 3 to 4 foot sluice, floored with a steel-punched screen, and begin operations. (For methods, see p. 77.) The water for sluicing is generally derived from some of the big irrigating canals or small streams in the mountains. This simple device intelligently handled will save a large percentage of the visible fine gold of the Snake River gravels, and is applicable as well to the large dredging operations. Some of these bars in the past have given this portion of the State a fair standing in the production of gold.

That part of Snake River which forms the boundary between Lincoln and Cassia counties, Idaho, was the scene several years ago of the most successful gold-dredging enterprise that has ever been conducted for the treatment of the extensive beds of fine gold-bearing gravels for which Snake River is noted. The dredge was operated by the Sweetzer-Burroughs Dredging Company, of Minidoka, whose plant and methods were described in detail in the Engineering and Mining Journal, February 15, 1902 (reprinted in the report of the Idaho inspector of mines, for 1904). This plant was a suction dredge that ran several years and handled 3,000 cubic yards per day, saving probably about half of the gold content of the gravel raised from the low bars in and along the borders of the stream between high and low water marks. This company's operations commenced in the spring of 1894, when it practically had the choice of the stream. The results obtained, the best layers of gravel being skimmed to about 6 feet, averaged all through less than 10 cents per cubic yard. After several years of continuous operation, which resulted in one $10,000 dividend, the enterprise was abandoned, as the possible margin of profit was too small to warrant its continuance.

Robert N. Bell, in writing of the Snake River gravels in the vicinity of Minidoka, Idaho, makes the following statement: [a]

> I am skeptical about the invisible gold contents of these gravel deposits, except the coated gold, which is readily recognized. The Snake River fine gold is finer than any natural placer gold that I know of. It is high grade, but requires fully 1,000 to 1,500 colors to weigh 1 cent in value. Yet under a powerful microscope each color is an individual nugget showing abrasion marks. These particles are even coated, touched, or spotted with a crystalline white film, with some foreign substance that looks like silica under the glass, and this is what makes it necessary to polish it in the grinding pan before it will amalgamate freely. The size of the particles ranges within comparatively narrow limits, but there is no gradual shading from the smaller colors into imperceptible dust, and if the gravel contains any invisible gold that can not be recognized in an ordinary pan with the naked eye, it must be locked up in the particles of heavy concentrates.

The Government dam at Minidoka has raised the water over an adjacent high terrace that represents an old river bed and contains some of the best values in fine gold along Snake River. This terrace is known as Diamond Bar, and the shallow water now covering it affords a pond with sufficient water to float a chain-bucket or suction dredge, either one of which is adapted for treating this ground. A plan to dredge the terrace has lately received considerable attention from promoters; and already one company has organized and purchased several claims near the lower end of the backwater, with a view of installing a dredge and taking advantage of the favorable situation created by the Government irrigation enterprise.

In May and June, 1906, before the water was ponded above the dam, some prospecting on these gravels was done by the United States Geological Survey. The land examined by L. G. Gillette and W. L. Walker consisted of certain claims along Snake River in Idaho which would be submerged when the lake formed by the dam at Minidoka

[a] In a letter to the writer, January 12, 1907.

was full. The claim farthest upstream that was examined was the Golden Treasure, about 25 miles above the dam. The bulk of the work was done in the neighborhood of the old placers in order to determine the value of the ground that was formerly considered profitable. It was found that the values were very irregularly distributed and in but few places equal to the claims made by those interested in the land. The prospecting was accomplished by means of test pits, panning, and sampling, the samples taken being shipped to Portland, Oreg., where they were treated and assayed by the Survey in connection with the black-sand investigation. The information gained by the field tests and the assay of samples is not such as to place a specific valuation on any particular claim; but the results derived give the average values carried by the ground over which the pits were distributed. Comparative values for the various samples were determined in a preliminary way, merely for comparative purposes, on the ground by the count of the gold colors, and thus ready knowledge was had as to the location and extent of the mineral-bearing material. It was found that in general the values were concentrated in the bottom of the loam and the upper portion of the underlying gravels. The surface soil or sandy loam is common and ranges in thickness from 2 to 12 feet or more. The gold was everywhere of the finest flourlike particles, a large percentage of which would pass through a 150-mesh screen. The rocks are in general much smaller than a man's head, although in a few places rocks large enough to interfere with dredging or other mining operations were encountered.

After the sampling and assaying were completed the remainder of the "undersize" was mixed and run over a Wilfley concentrating table to determine the minerals present and to see whether or not the gold could be saved by that type of machine. The results obtained were excellent on both the loam and the gravel. A charge of 2,172 pounds of loam assaying 10 cents per ton was fed to the table, and a concentrate weighing 6 pounds 14 ounces was obtained, which assayed $33.28 per ton. The assay of the middlings (30 pounds) and of the tailings (5 assay tons being used in the large crucibles) showed only a trace of gold. The gravel gave equally satisfactory results; 3,850 pounds assaying 8 cents per ton yielded 8 pounds 10½ ounces of concentrates assaying $34.01 per ton. The middlings (52½ pounds) and tailings contained only a trace.

No other minerals of any commercial importance were found. No platinum or monazite was observed and only a trace of zircon. The richest sample contained only 4 pounds of magnetite per ton. These results indicate that the percussion type of machine can be used advantageously in separating the Snake River fine gold from the loam and gravels, especially after preliminary concentration in ordinary sluice boxes and shunting the concentrates onto the tables by means of undercurrents. In the 25-mile stretch examined by Messrs. Gillette and Walker mining work was carried on only at the Sample placer claim, owned by W. H. Philbrick, who employed one stream in his ground-sluicing operations.

The following table shows the gold values in the placers along Snake River near the Minidoka dam. The location of the pits is shown on Pl. II (p. 78). The figures given under "Depth" indicate position with reference to the surface of the ground at which the samples were taken. "Percentage of oversize on 2 mm." indicates the portion too coarse to pass through a screen having openings 2 mm. (approximately one-twelfth of an inch) square. The "undersize" is that which passes through the screen. The value of the original gravel (oversize plus undersize) is given by the ton and by the yard, a yard being assumed at 1.3 tons. Under "Cumulative value" is given the average value of all material that would have to be moved in excavating to the depth indicated.

Gold values of Snake River placers in the vicinity of Minidoka dam, as determined in the black-sand investigation at Portland, Oreg.

Name of placer claim.	Owner.	Pit No.	Depth.		Percentage of oversize on 2 millimeters.	Value of undersize.	Value of original gravel.		Cumulative value.
			From—	To—			Per ton.	Per cubic yard.	
			Ft. in.	*Ft. in.*					
			....	8 0	.0	Trace.	$0.00	$0.00	$0.00
Diamond Bar....	Kinney...........	1	8 0	8 6	.7	$0.37	.37	.48	.03
			10 0	15 0	40.4	.12	.07	.09	.04
Do..........	.....do...........	2	5 4	9 4	15.6	.62	.52	.68	.29
			9 4	12 6	53.2	.04	.02	.03	.23
Do..........	.....do...........	3	6 0	8 0	48.0	.21	.11	.14	.03
Do..........	.....do...........	4	4 0	7 0	44.5	.33	.18	.23	.10
			4 0	6 0	71.6	.74	.21	.27	.09
Do..........	.....do...........	5	6 0	12 0	7.8	4.34	4.01	5.21	2.65
			12 0	14 0	76.9	.12	.03	04	2.31
Do..........	.....do...........	6	5 0	7 0	72.0	.50	.14	.18	.05
			7 0	11 0	63.1	None.	.00	.00	.03
Do..........	.....do...........	7	5 0	10 0	47.8	.41	.21	.27	.14
			....	3 10	10.2	None.	.00	.00	.00
Do..........	.....do...........	8	3 10	7 0	55.0	.08	.04	.05	.02
			7 0	8 6	....	.00	.00	.00	.00
			....	3 0	22.6	.33	.26	.34	.34
Do..........	.....do...........	9	3 0	4 6	73.2	.29	.08	.10	.26
			4 6	10 0	41.0	.21	.12	.16	.21
			2 0	3 0	14.1	.41	.35	.46	.15
Do..........	.....do...........	10	3 0	5 0	70.8	.99	.29	.38	.24
			5 0	9 6	9.0	.41	.37	.48	.35
Do..........	.....do...........	11	3 0	4 0	52.7	.37	.18	.23	.06
Do..........	.....do...........	12	3 8	4 6	31.9	.37	.25	.33	.06
			4 6	6 10	70.0	.79	.24	.31	.14
Do..........	.....do...........	13	3 6	5 0	63.8	.91	.33	.43	.13
			5 0	7 0	55.1	.08	.04	.05	.11
			6 0	2 6	33.1	.12	.08	.10	.08
			2 6	4 0	66.0	.50	.17	.22	.14
Do..........	.....do...........	14	4 0	7 0	....	....	....	....	.08
			7 0	8 6	6.8	None.	.00	.00	.06
			8 6	9 6	70.5	.04	.01	.01	.05
			1 6	3 0	32.9	.33	.22	.29	.15
Do..........	.....do...........	15	3 0	5 6	61.8	.33	.13	.17	.16
			5 6	5 9	54.7	.83	.38	.49	.17
Do..........	.....do...........	16	....	1 6	15.1	.16½	.13	.17	.17
			1 6	3 5	71.0	.62	.18	.23	.20
			....	1 8	24.7	.00	.00	.00	.00
Do..........	.....do...........	17	1 8	3 0	62.2	.25	.09	.12	.05
			3 0	7 0	56.3	.00	.00	.00	.02

Gold values of Snake River placers in the vicinity of Minidoka dam, as determined in the black-sand investigation at Portland, Oreg.—Continued.

Name of placer claim.	Owner.	Pit No.	Depth.				Percentage of oversize on 2 millimeters.	Value of undersize.	Value of original gravel.		Cumulative value.
			From—		To—				Per ton.	Per cubic yard.	
			Ft.	*in.*	*Ft.*	*in.*					
Diamond Bar....	Kinney..........	18	....		1	6	17.9	$0.08	$0.07	$0.09	$0.00
			1	6	2	6	52.7	.21	.10	.13	.11
			2	6	8	0	46.0	None.	.00	.00	.03
Do..........	.....do..........	19	3	6	6	0	52.3	.17	.08	.10	.04
Do..........	.....do..........	20	....		6	0	.7	.04	.04	.05	.05
			6	0	11	6	68	.00	.00	.00	.03
Do..........	.....do..........	21	....		6	6	3.4	.04	.04	.05	.05
			6	6	7	10	59.0	.21	.09	.12	.06
			7	10	8	10	54.5	.00	.00	.00	.05
Do..........	.....do..........	23	....		8	0	0	.12	.12	.16	.16
			8	0	10	0	41.9	.04	.02	.03	.14
Do..........	.....do..........	24	....		8	6	0	.04	.04	.05	.05
			8	6	10	0	59.4	.25	.10	.13	.06
Do..........	.....do..........	25	....		6	0	9.8	None.	.00	.00	.00
			6	0	7	0	54.8	.41	.19	.25	.03
Do..........	.....do..........	26	....		9	0	0	Trace.	.00	.00	.00
			9	0	9	6	59.2	1.28	.52	.68	.03
			9	6	11	6	63.2	.41	.15	.20	.06
Do..........	.....do..........	27	7	6	8	0	2.9	.08	.08	.10	.01
			8	0	9	0	49.5	Trace.	.00	.00	.01
Do..........	.....do..........	38	....		8	0	31.1	.08	.06	.08	.08
Do..........	.....do..........	40	....		11	0	8.5	.08	.07	.09	.09
Do..........	.....do..........	41	....		4	0	.7	.17	.17	.22	.22
			4	0	5	0	72.2	.87	.26	.34	.24
Do..........	.....do..........	42	....		6	6	0	.08	.08	.10	.10
			6	6	7	6	63.6	1.16	.42	.55	.16
Nebraska........	R. Lilly & Co.....	28	....		7	0	36.1	.41	.26	.34	.34
Do..........	.....do..........	29	....		7	0	11.5	None.	.00	.00	.00
Do..........	.....do..........	30	....		9	6	8.8	.29	.26	.34	.34
Do..........	.....do..........	31	....		7	0	2.6	.12	.12	.16	.16
			7	0	8	6	45.7	2.89	1.57	2.04	.49
Do..........	.....do..........	32	....		10	0	23.4	.29	.22	.29	.29
			10	0	10	6	23.4	.91	.70	.91	.32
Do..........	.....do..........	33	....		9	6	6.0	.17	.16	.21	.21
Do..........	.....do..........	34	....		7	0	36.4	.91	.58	.75	.75
Do..........	.....do..........	35	....		5	0	7.6	.04	.04	.05	.05
Do..........	.....do..........	36	....		4	0	15.8	.25	.21	.27	.27
			4	0	5	3	42.7	.04	.02	.03	.21
Do..........	.....do..........	37	....		9	6	2.6	.08	.08	.10	.10
Do..........	.....do..........	39	....		9	0	0	.04	.04	.05	.05
			9	0	10	3	46.9	.54	.29	.38	.09
Boise..........	.....do..........	43	4	8	7	8	57.7	1.07	.45	.59	.23
Do..........	.....do..........	44	....		9	0	....	None.	.00	.00	.00
			9	0	12	0	59.8	.12	.05	.07	.02
Do..........	.....do..........	45	....		11	0	0	.08	.08	.10	.10
Do..........	.....do..........	46	2	6	3	9	55.4	.12	.05	.07	.03
			3	9	8	0	38.9	.12	.07	.09	.06
Do..........	.....do..........	47	....		7	0	0	.12	.12	.16	.16
			7	0	14	0	54.3	.54	.25	.33	.24
Do..........	.....do..........	48	....		3	6	2.6	.17	.17	.22	.22
			3	6	5	6	58.3	.41	.17	.22	.22
			5	6	12	0	71.4	.04	.01	.01	.11
Do..........	.....do..........	49	....		10	0	22.8	None.	.00	.00	.00
Do..........	.....do..........	50	....		4	0	46.7	.08	.04	.05	.05
			4	0	11	0	35.1	.00	.00	.00	.02
Do..........	.....do..........	51	1	9	4	3	62.7	.04	.02	.03	.02
			4	3	9	0	36.0	.08	.05	.07	.05
Do..........	.....do..........	52	....		9	6	1.2	.08	.08	.10	.10
			9	6	11	6	38.8	.04	.02	.03	.09
Bessie Hannah...	.....do..........	22	2	6	3	0	30.0	.58	.41	.53	.09
			3	0	6	0	50.5	....	....	....	....
Do..........	.....do..........	53	....		5	6	5.4	None.	.00	.00	.00
			5	6	10	0	37.8	.62	.39	.51	.23
Do..........	.....do..........	55	....		9	6	20.4	.12	.10	.13	.13
Do..........	.....do..........	56	....		5	0	1.3	.04	.04	.05	.05
			5	0	10	0	24.7	.12	.09	.12	.08
Goldleaf	Dunn, Hand & Hughes.	57	....		8	6	7.4	None.	.00	.00	.00
			8	6	13	0	40.6	None.	.00	.00	.00
Do..........	.....do..........	58	....		8	0	18.7	.62	.50	.65	.65
Do..........	.....do..........	59	....		8	0	27.8	None.	.00	.00	.00
Do..........	.....do..........	60	3	0	10	6	51.4	.08	.04	.05	.04
Do..........	.....do..........	61	1	0	8	0	18.4	.25	.20	.26	.23
Do..........	.....do..........	63	5	0	6	6	54.8	.12	.05	.07	.02
March Morning ..	Steele & Lockhart.	62	....		....		None.	None.	None.	None.	None.
Do..........	.....do..........	64	7	0	8	0	38.4	.50	.31	.40	.05

Gold values of Snake River placers in the vicinity of Minidoka dam, as determined in the black-sand investigation at Portland, Oreg.—Continued.

Name of placer claim.	Owner.	Pit No.	Depth. From— Ft.	Depth. From— in.	Depth. To— Ft.	Depth. To— in.	Percentage of oversize on 2 millimeters.	Value of undersize.	Value of original gravel. Per ton.	Value of original gravel. Per cubic yard.	Cumulative value.
March Morning	Steele & Lockhart	65	....		9	0	1.4	$0.00	$0.00	$0.00	$0.00
Do	....do	66	4	6	11	0	0	None.	None.	None.	.00
Do	....do	67		6	13	0	4.3	None.	None.	None.	.00
Do	....do	68	9	6	11	6	40.9	.12	.07	.09	.02
Do	....do	69	....		4	0	52.8	Trace.	.00	.00	.00
Grasshopper	Dunn, Hand & Hughes.	70	4	0	6	0	46.1	None.	.00	.00	.00
Do	....do	71	....		2	6	10.0	None.	.00	.00	.00
			2	6	6	0	59.1	.50	.20	.26	.15
Excelsior	....do	72	....		3	6	32.3	None.	.00	.00	.00
			3	6	9	0	4.2	.17	.16	.21	.13
Do	....do	73	....		2	0	9.5	.12	.11	.14	.13
			2	0	9	0	41.6	None.	.00	.00	.03
Albert	E. H. Albert	74	4	0	9	0	46.1	.08	.04	.05	.03
Do	....do	75	12	0	17	0	31.2	.70	.48	.62	.18
Do	....do	76	18	0	21	0	47.1	None.	.00	.00	.00
Do	....do	77	9	6	18	0	40.5	None.	.00	.00	.00
Do	....do	78	3	6	8	0	56.2	.33	.14	.18	.10
Do	....do	79	6	6	14	0	61.9	.08	.03	.04	.02
Do	....do	80	10	6	14	6	60.9	.08	.03	.04	.01
Do	....do	82	5	0	7	0	46.6	None.	.00	.00	.00
Albert (from east end).	....do	105	5	6	7	6	73.2	.58	.16	.21	.06
Do	....do	110	3	6	6	6	48.8	None.	.00	.00	.00
Gold Crown	Dunn, Hand & Hughes.	85	1	6	6	0	36.6	.17	.06	.08	.06
Montana P	....do	87	2	0	6	6	37.6	.37	.23	.30	.21
Oneida Claim	O. L. Cleveland	89	3	0	9	0	75.4	.12	.03	.04	.05
Do	....do	90	9	6	14	0	69.6	.74	.22	.29	.10
			14	0	18	0	71.0	.04	.01	.01	.08
Do	....do	91	9	6	14	6	78.8	.48	.10	.13	.05
Do	....do	92	13	0	15	3	52.6	.58	.27	.35	.05
Do	....do	93	11	6	13	3	58.3	None.	.00	.00	.00
Do	....do	94	8	6	12	0	52.4	.52	.25	.32	.09
Cassia	....	95	8	0	9	0	66.9	.37	.12	.16	.02
			8	0	13	0	62.5	.12	.05	.07	.03
Do	....	96	6	6	10	6	62.5	.70	.26	.34	.13
Do	....	97	9	6	11	6	48.8	Trace.	.00	.00	.00
			11	6	15	0	32.1	.08	.05	.07	.02
Do	....	99	6	6	9	6	59.6	.54	.22	.29	.09
			9	6	13	6	48.0	.17	.09	.12	.10
Do	....	101	9	5	13	0	51.0	.17	.08	.10	.03
			13	0	17	0	7.2	.04	.04	.05	.03
Do	....	102	9	6	14	0	47.8	.29	.15	.20	.07
Do	....	103	5	6	12	0	1.3	.17	.17	.22	.12
			12	0	16	0	56.6	.04	.02	.03	.10
Do	....	104	8	6	12	0	44.4	.91	.51	.66	.19
Agricultural holdings.	O. L. Cleveland	106	4	6	9	0	58.5	None.	.00	.00	.00
Do	....do	107	4	6	7	0	67.0	None.	.00	.00	.00
			7	0	11	0	56.0	.17	.07	.09	.04
Do	....do	108	6	6	11	4	60.6	.25	.10	.13	.06
			11	4	12	4	26.8	None.	.00	.00	.05
Do	....do	109	3	6	6	0	25.0	None.	.00	.00	.00
			6	0	10	0	46.5	None.	.00	.00	.00
Do	....do	a105	5	6	7	6	73.2	.58	.16	.21	.06
Do	....do	a110	3	6	6	6	48.8	None	.00	.00	.00
Heigh	W. H. Philbrick	112	3	6	5	0	43.3	None.	.00	.00	.00
Do	....do	113	5	6	8	0	62.2	.17	.06	.08	.03
			8	0	12	6	66.3	.25	.08	.10	.05
Do	....do	114	6	6	8	6	61.7	.29	.11	.14	.03
			8	6	11	0	53.9	.17	.08	.10	.05
Do	....do	115	8	6	12	8	18.4	.79	.64	.83	.27
			12	8	16	0	73.9	.12	.03	.04	.22
Do	....do	116	11	6	20	0	50.0	.12	.06	.08	.03
Do	....do	117	4	0	8	0	36.7	.21	.13	.17	.08
Do	....do	118	3	0	13	0	61.6	.17	.07	.09	.06
Do	....do	119	13	6	17	0	48.9	.21	.11	.14	.03
			17	0	20	0	62.4	.04	.02	.03	.03
Do	....do	120	3	0	5	0	45.0	.17	.09	.12	.05
Do	....do	121	7	0	15	0	52.0	.08	.04	.05	.03
Do	....do	122	6	0	8	0	59.1	.04	.02	.03	.01
			8	0	17	0	52.3	.17	.08	.10	.06

a Nos. 105 and 110 are just over the line, on E. H. Albert's property.

Gold values of Snake River placers in the vicinity of Minidoka dam, as determined in the black-sand investigation at Portland, Oreg.—Continued.

Name of placer claim.	Owner.	Pit No.	Depth.		Percentage of oversize on 2 millimeters.	Value of undersize.	Value of original gravel.		Cumulative value.
			From—	To—			Per ton.	Per cubic yard.	
			Ft. in.	*Ft. in.*					
Hegiht	W. H. Philbrick	123	11 6	15 6	51.0	$0.17	$0.08	$0.10	$0.03
Do	do	124	13 0	18 0	74.1	.04	.01	.01	.00
Do	do	125	2 6	7 0	72.1	.04	.01	.01	.02
			7 0	11 0	72.1	.04	.01	.01	.01
Do	do	126	4 0	5 0	48.5	.29	.15	.20	.04
			5 0	7 0	70.0	.54	.16	.21	.09
Do	do	127	16 0	20 0	64.5	.12	.04	.05	.01
Sample	do	128	3 6	9 0	50.0	.21	.11	.14	.09
Do	do	129	4 0	10 0	51.8	.06	.03	.04	.01
Do	do	130	4 6	9 0	43.8	.50	.28	.36	.18
Do	do	131	2 0	6 0	60.8	.25	.10	.13	.09
Do	do	132	5 6	11 6	52.1	.12	.06	.08	.04
Golden Treasure Bar.	do	133	2 6	7 0	69.6	.29	.09	.12	.08

Detailed records of each of the sections at the pits included in the foregoing table are given in the report by David T. Day on placer claims above the Minidoka dam which is now on file in the office of the Reclamation Service at Washington, D. C., and from which the above table is compiled.

The gravels along Snake River in the vicinity of Wapi, Idaho, have been worked by Dunn & Hand, all of their workings being on old high bars or terraces (part of which are now under water) along the present river channel. C. H. Hand states that the gold here is a very fine flake gold, and amalgamates readily. The gold is scattered through the gravel but is usually best at the top of the beds. It occurs in heaviest particles in the oldest bars. The pay streaks run from a few inches to 6 or 7 feet in depth, but in some places exceed 22 feet, at which depth the gold has run as high as 22 cents per cubic yard. Where bed rock lies at the shallow depths, say from 6 to 8 feet below the surface, the pay streak in some places rests on the bed rock. Occasionally two or more pay streaks are encountered, one on bed rock and the other higher in the gravels or near the top. It is, however, exceptional to find the pay streak on bed rock. The bars in this locality are very extensive, amounting to hundreds of acres. Actual clean-up, by sluicing some thousand of yards, shows a value of a little more than 20 cents per cubic yard for some million of yards. Gravels of much higher grade occur at some places in thin seams. For a short distance these may run as high as several dollars per cubic yard. The above averages are, however, for gravels worked from 12 to 15 feet in depth and include both the gravels and the surface soil. Besides the gold, the gravels for the above depths carry about three-fourths of 1 per cent of black sand and other heavy minerals.

Two or three enterprises now on foot at different points along the Snake River will test the problem of saving the possible by-products of the gravels in addition to the gold content. One of these is being undertaken at a point on the Oregon side of the river a short distance below Weiser, Idaho, and another at a point a short distance above American Falls, Idaho. The results of these efforts will be watched with much interest, for, if any margin of profit at all can be made in which platinum becomes an important factor in the output, it will be important to the country at large, as the business might be greatly extended, since there are billions of yards of these low-grade gold and platinum-bearing gravels along the banks of Snake River. The portion of Snake River below the Grand Canyon that flows through Bingham, Blaine, Oneida, Cassia, and Lincoln counties, Idaho, yielded in 1905 approximately 1,300 fine ounces of gold, valued at a little more than $26,000.

PLATINUM IN THE SNAKE RIVER AURIFEROUS GRAVELS.

The recent experiments of David T. Day, of the United States Geological Survey, at Portland, Oreg., on the heavy placer concentrates of the Pacific slope, to determine their value in other metals and minerals besides gold, included a number of samples of Snake River concentrates, nearly all of which yielded from a trace to an appreciable amount of platinum, but Doctor Day doubts whether many of the results were obtained from representative samples. The subject is interesting and well worthy of close and intelligent investigation. It may prove, however, that under the present state of the platinum market, the platinum values are too thinly scattered along this stream to be of much value unless they are combined with the concentrates and have largely passed unnoticed. The actual contents of magnetite and similar heavy residues in these gravel beds, as nearly as has been determined, is from one-fourth to one-third of 1 per cent of the gravel, and when their visible free-gold content is properly amalgamated out the residue will not assay over $5 in gold per ton.

During the past year Robert N. Bell, State mine inspector of Idaho, visited the point on Snake River from which the highest results in platinum were reported during the progress of the Portland fair. A sample taken at this point yielded platinum at the rate of eighteen one-hundredths of an ounce per ton and several hundred dollars in gold per ton. Mr. Bell learned that the sample was selected from the first burlap on one of the "machine" tables, with the fine gold left in, and probably represented a concentration of several thousand to one. A subsequent sample of clean black concentrates taken from below the grinding pan, after the free gold had been amalgamated out, was sent to Doctor Day and gave a result of $3 gold per ton and only a trace of platinum.

The gravel containing the gold and platinum is usually well worn and small, affording ideal conditions for dredging and with a large enough plant and intelligent handling may be made to pay. The possible margin of profit, however, working for the gold content alone, would be small and unattractive, unless associated values of gold or platinum not apparent to ordinary methods of saving can be recovered. That platinum in metallic form is associated with the gold in these gravel beds can not be questioned, for while it can rarely be seen in panning it invariably shows in cleaning amalgam. In the operation of the Sweetzer-Burroughs dredge near Minidoka, it was always observed at clean-up time, appearing as ashy gray metallic particles floating on the "quick" when the hard amalgam was thinned down with more "quick" for the purpose of separating foreign matter from the gold. A quarter of an ounce of clean platinum recovered in this manner is now in the possession of Lewis Sweetzer, of Rupert, Idaho. It is perfectly clean gray metal in scaly particles and about as fine as the fine gold.

SOURCE OF GOLD.

The source of the Snake River fine flour or flake gold is unknown. The fineness of the individual particles and the abrasion marks seen on some of the pieces suggest that they have been carried for some distance. From the evidence gathered within the area studied this season it seems likely that the gold was carried from regions lying farther north and northeast. It was probably derived from the older rocks of the Teton and Gros Ventre ranges or from the region of the later intrusives of the upper Snake Valley. The old bars and benches containing the gold were built up in much the same manner as those now forming in the river, and some of the gold particles have been worked over and over again by the river until they are finally mined in their present places.

The thickness and value of the pay streaks is no doubt dependent on the local conditions under which they were deposited. The gradient of the stream as well as the volume of the water, its turbidity, and the time during which it flowed in the same channel would affect the distribution, thickness, and richness of the pay streaks. Unlike other gold placers those of Snake River do not increase in gold values as bed rock is approached, for the gold is usually more plentiful in the gravel banks between present and former high and low watermarks than at the deeper horizons. By the completion of the Milner and Minidoka dams the flow of the stream has been absolutely stopped for several days at two points along its course within the past two years, and its bed rock has thus been laid bare for miles during periods in which its potholes and crevices were searched in vain for paying gold values.

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 108 and 109 and for lead and zinc on page 128. 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 9 to 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.

Ball, S. H. Geological reconnaissance in southwestern Nevada and eastern California. In Bulletin No. 285, pp. 53–73. 1906. Also Bulletin No. 308.

Barrell, Joseph. Geology of the Marysville mining district, Montana. Professional Paper No. 57. 1907.

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, Nev. 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, Colo.; 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, Colo. 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.

——— Ore deposits of Bear Creek, near Silverton. In Bulletin No. 285, pp. 25–27. 1906.

——— Notes on the Manhattan district [Nevada]. With Ransome and Garrey in Bulletin No. 303.

Gale, H. S. Hahns Peak gold field. In Bulletin No. 285, pp. 28–34. 1906.

Garrey, G. H. Notes on the Manhattan district [Nevada]. With Ransome and Emmons in Bulletin No. 303.

Graton, L. C. Gold and tin deposits of the southern Appalachians; with notes on the Dahlonega mines by Waldemar Lindgren. Bulletin No. 293. 134 pp. 1906.

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, Colo. In Bulletin No. 260, pp. 78–84. 1905.

Lindgren, Waldemar. The gold-silver mines of Ophir, Cal. 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.

——— 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 No. 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.

——— The Annie Laurie mine, Piute County, Utah. In Bulletin No. 285, pp. 87–90. 1906.

——— Notes on the Dahlonega mines. In Bulletin No. 293, pp. 119–128. 1906.

LINDGREN, WALDEMAR, and GRATON, L. C. Mineral deposits of New Mexico. In Bulletin No. 285, pp. 74–86. 1906.

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

——— ——— Geology and gold deposits of the Cripple Creek district, Colorado. Professional Paper No. 54. 516 pp. 1906.

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

MACDONALD, D. F. Economic features of northern Idaho and northeastern Montana. In Bulletin No. 285, pp. 41–52. 1906.

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.

——— Preliminary account of Goldfield, Bullfrog, and other mining districts in southern Nevada; with notes on the Manhattan district by G. H. Garrey and W. H. Emmons. Bulletin No. 303. 98 pp.

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 Creek 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, Nev. In Bulletin No. 260, pp. 132–139. 1905.

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

——— Ore deposits of the Silver Peak quadrangle, Nevada. Professional Paper 55. 174 pp. 1906.

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.

——— ——— The Idaho Springs mining district, Colorado. In Bulletin No. 285, pp. 35–40. 1906.

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, Md. 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, Mont. 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.