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MINERAL RESOURCES OF ALASKA

REPORT ON PROGRESS OF INVESTIGATIONS IN

1910

BY

ALFRED H. BROOKS AND OTHERS

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PREFACE.

This volume is the seventh[1] of the series issued annually by the Geological Survey, each of which summarizes for the year both the conditions of the mining industry and the most important results obtained by the investigations of the mineral wealth. The purpose of these reports is to furnish a convenient handbook for those interested in the mining industry of Alaska and to make available the more important economic results of the year's surveys in advance of the publication of complete reports, which usually require at least six months for office preparation by the author and then, because each must await its turn, from two or three months to a year for publication. In a region like Alaska, where developments are going on rapidly, such a delay after the completion of the field work may seriously impair the value of the publication to the prospector. On the other hand, the publication of the advance statements in these progress reports implies hasty preparation and in some cases the presentation of conclusions which may be changed by the more exhaustive office study. Therefore those interested in any particular district are urged to procure a copy of the more complete report as soon as it is issued.

The same arrangement will be maintained in this volume as in those previously issued. First will be presented papers of a general character, followed by those referring to special districts, which will be arranged geographically from south to north. This bulletin contains 15 papers by 11 authors, of which 2 deal with administrative

[1] Report on progress of investigation of the mineral resources of Alaska, 1904: Bull. U. S. Geol. Survey No. 259, 1905; Idem, 1905: Bull. 284, 1906; Idem, 1906: Bull. 314, 1907; Idem, 1907: Bull. 345, 1908; Idem, 1908: Bull. 379, 1909; Idem, 1909: Bull. 442, 1910.

matters, 3 are summaries of some features of the mining industry, and the remainder deal more specifically with problems of economic geology.

In the preparation of the summaries of the mining industries the writer, as in previous years, has in part been dependent on information gleaned from various sources, for it is impossible with the small force available to have a representative of the Survey visit each of the many Alaska mining districts. These summaries could not be prepared were it not for the cordial cooperation of the residents of the Territory, including mine operators, Federal officials, officers of banks and of transportation and commercial companies, mining engineers, and many prospectors. It would be impossible to enumerate all those who have contributed information, but special acknowledgment should be made to the following: The Director of the Mint; S. Irvine Stone, of Kodiak; Melvin Dempsey, of Dempsey; H. S. Ferris and H. P. Gallagher, of Susitna; W. M. Harrison, of Cache Creek; E. R. Stivers, of Fortymile; J. J. Hillard, of Eagle; Ralph Donaldson, of Rampart; Benjamin F. Baker and Joseph H. Eglar, of Tofty; William A. Fitzpatrick, of Chena; D. H. Boyer, Alaska Pacific Express Co., First National Bank, and Washington, Alaska & Fairbanks Banking Co., of Fairbanks; F. J. Marsh, of Caro; John A. Dexter, of Chenik; C. W. Thornton, of Solomon; and J. W. J. Reed, of Nome.

During the season of 1910, 12 parties were engaged in Alaskan surveys for varying lengths of time between April 1 and October 17. In addition to these the geologist in charge did some field work. The personnel of these parties included 12 geologists, 4 topographers, 2 engineers, and 27 packers, cooks, etc. In addition to these some gage readers were employed who gave only part of their time to the work. Four of the parties were engaged in geologic work, two in both geologic and topographic surveys, four in topographic surveys, and two in investigating water resources.

The areas covered by geologic reconnaissance surveys, on a scale of 1 : 250,000 (4 miles to the inch), amount to 8,635 square miles; by detailed geologic surveys, on a scale of 1 : 62,500 (1 mile to the inch), 321 square miles. Much of the time of the geologists was devoted to the investigation of special field problems in the important mining districts, the results of which can not be presented areally. Some 13,815 square miles of topographic reconnaissance surveys, on a scale of 1 : 250,000 (4 miles to the inch), and 36 square miles of detailed topographic surveys, on a scale of 1 : 62,500 (1 mile to the inch), were completed.

In 1910, 54 gaging stations were maintained in the Yukon-Tanana region for an average of 143 weeks each, furnishing data on the water resources of about 4,700 square miles. Fifteen gaging stations were also maintained for 170 weeks in Seward Peninsula, yielding data on the run-off of some 1,800 square miles.

To state the work geographically, two parties were in southeastern Alaska, three in the Copper River and Susitna basins, one in the Matanuska Valley, three in the upper Yukon basin, two in the Innoko-Iditarod region, and one in the Kobuk region.

Among the important results of the year were the completion of the detailed survey of that part of the Juneau gold belt which lies between Salmon Creek and Berners Bay and of the part of the Matanuska coal field lying west of Chickaloon River and the completion of the geologic and topographic reconnaissance mapping of the Bonnifield district, the Valdez Creek region, and the most important part of the Innoko and Iditarod region. The accumulation of data on the water resources of the Yukon-Tanana region and of Seward Peninsula is yielding results of importance to the placer-mining industry.

The following table shows the allotment, including both field and office expenses, of the total appropriation of $90,000 to the districts investigated:

Allotment to Alaskan surveys and investigations in 1910.

Southeastern Alaska	$5,100
Copper River region	27,000
Matanuska region	9,600
Upper Yukon basin	23,800
Innoko-Iditarod region	14,100
Northwestern Alaska, including Seward Peninsula	10,400
	90,000

In the following table the approximate amount of money devoted to each class of investigations and surveys is indicated. It is not possible always to give the exact figures, as in some cases the same party or even the same man has carried on two different kinds of work, but this statement will help to elucidate a later table which will summarize the complete areal surveys.

Approximate allotments to different kinds of surveys and investigations in 1910.

Geologic reconnaissance surveys	$26,500
Detailed geologic surveys	11,500
Special geologic investigations	2,500
Topographic reconnaissance surveys	32,000
Detailed topographic surveys	1,600
Investigation of water resources	4,600
Collection of statistics of mineral production	1,100
Miscellaneous, including clerical salaries, administration, inspection, instruments, office supplies, and equipment	10,200
	90,000

Allotments for salaries and field expenses, 1910.

Scientific and technical salaries	$29,330
Field expenses	51,765
Clerical and other office salaries	8,905
	90,000

The following table exhibits the progress of the Alaskan investigations and the annual grant of funds since systematic surveys were begun in 1898. It should be noted that a varying amount is expended each year on special investigations, yielding results which can not be expressed areally.

Progress of surveys in Alaska, 1898–1910.[a]

Year.	Appropriation.	Areas covered by geologic surveys.			Areas covered by topographic surveys.[b]					Water resources investigations.	
		Exploratory (scale 1:625,000 or 1:1,000,000).	Reconnaissance (scale 1:250,000).	Detailed (scale 1:62,500).	Exploratory (scale 1:625,000 or 1:1,000,000).	Reconnaissance (scale 1:250,000; 200-foot contours).	Detailed (scale 1:62,500; 25, 50, or 100 foot contours).	Lines of levels.	Bench marks set.	Gaging stations maintained part of year.	Stream-volume measurements.
		Sq. m.	*Sq. m.*	*Sq. m.*	*Sq. m.*	*Sq. m.*	*Sq. m.*	*Miles.*			
1898	$46,189.60	9,500			12,840	2,070					
1899	25,000.00	6,000			8,690						
1900	60,000.00	3,300	6,700		630	11,150					
1901	60,000.00	6,200	5,800		10,200	5,450					
1902	60,000.00	6,950	10,050		8,330	11,970	96				
1903	60,000.00	5,000	8,000	96		15,000					
1904	60,000 00	4,050	3,500		800	6,480	480	86	19		
1905	80,000.00	4,000	4,100	536		4,880	787	202	28		
1906	80,000.00	5,000	4,000	421		13,500	40			14	286
1907	80,000.00	2,600	1,400	442		6,120	501	95	16	48	457
1908	80,000.00	2,000	2,850	604		3,980	427	76	9	53	556
1909	90,000.00	6,100	5,500	450	6,190	5,170	444			81	703
1910	90,000.00		8,635	321		13,815	36			69	429
	871,189.60	60,700	60,535	2,870	47,680	99,585	2,811	459	72		
Percentage of total area of Alaska		10.35	10.32	0.49	8.16	16.98	0.48				

[a] The areas presented in this table differ somewhat from those published previously to 1909. This is due in part to the reclassification of the work and in part to the fact that the areas have been more carefully scaled from the maps than formerly.
[b] In addition to the above the International Boundary Survey and the Coast and Geodetic Survey have made surveys of parts of Alaska.

GEOGRAPHIC DISTRIBUTION OF INVESTIGATIONS.

GENERAL WORK.

The writer was engaged in office work at Washington until August 3, when he proceeded to Alaska, reaching Valdez on August 15. A day was spent in visiting the Cliff mine, and the journey was continued to Seward and then to Knik, two days being spent en route in studying the geology in the vicinity of Kern Creek. From Knik the writer proceeded to Mr. Martin's camp, which was reached on August 23. The following two weeks were spent in studying the geology of the Matanuska coal field, and then the writer returned to Seward. A day at Knik and several days at Seward were utilized in collecting data to be used for planning subdivisional surveys in this general region. (See pp. 15–20.) Returning, the writer reached Washington on September 30.

Of the time spent in the office the geologist in charge has devoted about 30 days to the completion of the Mount McKinley report (Professional Paper 70), about 50 days to the progress report, 15 days to subdivisional surveys (see pp. 15–20), and the rest to routine and miscellaneous matters.

R. H. Sargent continued the general supervision of the topographic surveys and map compilation, as in the previous year, but since July 1 his time has been largely devoted to the subdivisional surveys of Alaska public lands.

E. M. Aten continued as office assistant to the geologist in charge and supervised the office work during the writer's absence in the field. He also continued to assist in the collection of statistics of production of precious metals in Alaska.

The office study of the problems relating to the stratigraphy of Alaskan Tertiary coal measures was continued by W. W. Atwood during such time as he could spare from his college work. As the correlating of the coal measures of different parts of the Territory depends on the determination of their fossil plants, Arthur Hollick was employed for a part of the year on a systematic study of the large amount of paleobotanic material already collected.

SOUTHEASTERN ALASKA.

Adolph Knopf was employed from June 3 to September 7 in completing the detailed geologic mapping and study of the mineral resources of the Eagle River region. In this time he covered an area of 125 square miles. He then devoted 11 days to studying special mining problems near Juneau, 5 days to the Sitka mining district, and 11 days to collecting data on the mining developments in other parts of southeastern Alaska. (See pp. 94–110.)

J. W. Bagley, assisted by C. E. Giffin, spent the time from May 6 to June 6 in detailed topographic mapping of an area of 36 square miles in the vicinity of Mendenhall River, thus completing the surveying of the Eagle River district.

C. W. Wright was employed from July 6 to September 17 in continuing the work of preparing a report on the geology and mineral resources of Kasaan Peninsula and Hetta Inlet region. Unfortunately, he was called back to his professional work in Sardinia before he could complete his report, but he has promised an early completion.

COPPER RIVER AND SUSITNA REGION.

D. C. Witherspoon and C. E. Giffin began a topographic reconnaissance survey in the upper Chistochina region on July 1 and carried it westward into the Susitna basin, including the Valdez Creek placer district. The party was divided into two sections and continued work until September 12, covering an area of 4,980 square miles.

F. H. Moffit, assisted by B. L. Johnson, made a geologic reconnaissance survey of the southern front of the Alaska Range between the Fairbanks trail and Valdez Creek. He also made a reexamination of the Chistochina placer district, which had previously been mapped by W. C. Mendenhall. The Moffit party began work July 8 and continued until September 3. A geologic reconnaissance map of about 1,000 square miles was completed, in addition to which the topographic surveys and geologic notes furnished by the Witherspoon party furnished a general knowledge of the areal distribution of the principal formations over some 2,000 square miles. A preliminary statement of Mr. Moffit's results is presented on pages 112–126.

PRINCE WILLIAM SOUND AND KENAI PENINSULA.

No field work was done in the Prince William Sound and Kenai Peninsula regions other than that accomplished by the geologist in charge (p. 8). U. S. Grant has continued, so far as his collegiate duties permitted, the work of writing a report on the eastern part of the Kenai Peninsula.

MATANUSKA VALLEY.

G. C. Martin, assisted by F. J. Katz and Theodore Chapin, made a detailed geologic survey of that part of the Matanuska coal field lying between Moose Creek on the west and Chickaloon River on the east. An area of 196 square miles was surveyed during the period extending from June 3 to September 8. (See pp. 128–138.) At the close of the season Mr. Katz, assisted by Mr. Chapin, spent about a week in studying the mineral resources of the Willow Creek region. (See pp. 139–151.)

UPPER YUKON BASIN.

No geologic field work was done in the Yukon-Tanana region, but L. M. Prindle spent nine months of the year in preparing a detailed report on the region adjacent to Fairbanks and a more general report on the Fairbanks quadrangle. C. E. Ellsworth and G. L. Parker continued the study of the water resources of the Yukon-Tanana region which was begun in 1907. They began field work at Fairbanks on April 1 and then extended it into the Birch Creek district. Mr. Parker continued stream gaging in the Fairbanks and Birch Creek districts until September 1, when he went to Nome (p. 12). After organizing the work in these two districts, Mr. Ellsworth went to Eagle, which he reached on June 11, and began a systematic study of the water supply of the Fortymile region. This work was continued until September 19. A summary of the results of these investigations is presented on pages 173–217 of this volume.

J. W. Bagley, topographer, and S. R. Capps, geologist, carried a topographic and geologic reconnaissance survey from the upper Nenana Valley eastward to Delta River. The area surveyed includes 3,135 square miles and is bounded on the south by the crest of the Alaska Range and on the north by the lowlands of the Tanana Valley. These surveys were begun on June 26 and completed on September 13. The area surveyed includes the Bonnifield placer district and the larger part of the Nenana coal field. (See pp. 218–235.)

INNOKO-IDITAROD REGION.

The continued interest in the placer-gold deposits of the Innoko basin, including the newly discovered Iditarod placers, led to extending the work previously done in this field. G. C. Anderson made a topographic reconnaissance survey of an area of 3,200 square miles, extending southward from Ruby Creek, on the Yukon, across the upper Innoko Valley, and including much of the Iditarod basin. A. G. Maddren, assisted by H. E. Birkner, made a geologic reconnaissance survey of about 2,000 square miles of the most important part of the same region, besides investigating the placers of the Innoko and Iditarod districts. (See pp. 236–270.) The work was begun on June 19 and continued until September 16.

NORTHWESTERN ALASKA.

P. S. Smith and H. M. Eakin carried a geologic and topographic reconnaissance survey from the Koyukuk to Kobuk River. The party landed near the mouth of Hogatza River on June 22 and traveled overland to Dahl Creek, on the Kobuk. (See pp. 271–305.) A contract had been made to have supplies delivered at this point, but an accident had prevented delivery and the party was therefore forced to abandon the original plan of extending the survey southwest to Seward Peninsula and made its way down the Kobuk by small boat. This, however, gave opportunity to pay a hasty visit to the newly discovered Squirrel River placer district (see pp. 306–319), where the field work was ended on August 21. In spite of the season's work being curtailed by loss of supplies, an area of 2,500 square miles was covered by geologic and topographic reconnaissance surveys.

Systematic investigations of the water supply of Seward Peninsula have been carried on each year since 1906. The need of investigations in other parts of Alaska made it impossible to detail an engineer to continue this work in 1910. Through the cooperation of a number of mine operators it has been possible to keep up some gaging stations during the open season of 1910. In addition to the data thus obtained, G. L. Parker spent from September 15 to October 18 in Seward Peninsula in collecting the gage readings furnished by individuals and in making stream measurements. All these data are now being used in the preparation of a summary report on the water resources of Seward Peninsula.

COLLECTION OF STATISTICS.

As in previous years, the statistics of the gold, silver, and copper production of Alaska were collected by the writer, assisted by members of the field force and by Mr. Aten. Every year a larger percentage of the operators show their interest in this work by furnishing data of production. There are, unfortunately, still a rather large number of placer-mine operators who neglect to make returns of production, though the schedules are mailed to them each year. Such action, by decreasing the accuracy of the published totals for each district, injures the mining industry. It is believed that a large part of those who fail to report their production ignore the request sent by schedule because of the rush of work during the short open mining season. There may be some, however, who dislike to reveal their gold production, even to the Geological Survey. Those operators who have hesitated to furnish the desired information for fear it might be used to their disadvantage are reminded of the fact that the Geological Survey has received confidential information from practically every mining corporation in the States for many years and has never been charged with betraying a confidence. The figures furnished are used only to make up totals of districts, and every precaution is taken to prevent their being published in any way to indicate the output of individuals or corporations unless permission has been explicitly granted in writing.

The attention of all those interested in the advancement of the mining industry of Alaska is directed to the fact that it will be greatly to the advantage of this industry if accurate figures of the gold output of each district are published. If funds were available for sending a representative into each district to collect the required information in person, complete and reliable figures could undoubtedly be had. As it is, the work is still largely done by correspondence, and the address list of operators is by no means complete. It is expected, however, that soon every operator in the Territory will report his production, so that accurate totals for each district can be published. Until this is done the figures of production can be only approximate. Fortunately, there are other though less exact sources of information.

The statement of placer-gold production as presented is, then, based in part on the returns from operators and in part on data furnished by bankers, express companies, Federal officials, and other residents of Alaska.

PUBLICATIONS ISSUED OR IN PREPARATION.

During 1910 the Survey published five bulletins relating to Alaska. Three bulletins, one professional paper, and two maps are in press. The authors' work on two other reports, to appear as bulletins, has been completed, and illustrations for these are being prepared. The office work on eight other reports is sufficiently advanced to make it reasonably certain that they will be ready to submit for publication on or before the 1st of July, 1911. Six other reports will probably be submitted during the year 1911. The reports in press or in preparation include 14 new topographic maps, to be published on scales of 1:500,000, 1:250,000, or 1:62,500.

REPORTS ISSUED.

The Innoko gold-placer district, Alaska, with accounts of the central Kuskokwim Valley and the Ruby Creek and Gold Hill placers, by A. G. Maddren. Bulletin 410.

Mineral resources of the Nabesna-White River district, Alaska, by F. H. Moffit and Adolph Knopf; with a section on the Quaternary, by S. R. Capps. Bulletin 417.

Geology and mineral resources of the Solomon and Casadepaga quadrangles, Seward Peninsula, Alaska, by Philip S. Smith. Bulletin 433.

Mineral resources of Alaska in 1909, by A. H. Brooks and others. Bulletin 442.

Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska, by U. S. Grant and D. F. Higgins. Bulletin 443.

REPORTS IN PRESS.

The Mount McKinley region, Alaska, by A. H. Brooks; with descriptions of the igneous rocks and of the Bonnifield and Kantishna districts, by L. M. Prindle. Professional Paper 70.

Geology and mineral resources of the Berners Bay region, by Adolph Knopf. Bulletin 446. [Issued February 16, 1911.]

Geology and mineral resources of the Nizina region, Alaska, by F. H. Moffit and S. R. Capps. Bulletin 448.

Geologic reconnaissance in southeastern Seward Peninsula and Norton Bay-Nulato region, Alaska, by P. S. Smith and H. M. Eakin. Bulletin 449. [Issued June 17, 1911.]

REPORTS IN PREPARATION.

The Yakutat Bay earthquake of September, 1899, by R. S. Tarr and Lawrence Martin. Professional Paper 69.

Geology and mineral resources of parts of the Alaska Peninsula, by W. W. Atwood; including geologic and topographic reconnaissance maps. Bulletin 467.

Geologic reconnaissance of the Iliamna region, Alaska, by G. C. Martin and F. J. Katz, including geologic and topographic reconnaissance maps. Bulletin 485.

Geology and ore deposits of Kasaan Peninsula and the Copper Mountain region, Prince of Wales Island, by C. W. Wright; including detailed geologic and topographic maps.

Geology of Glacier Bay and Lituya region, by F. E. Wright and C. W. Wright, including geologic reconnaissance maps.

Geology and mineral resources of the Eagle River region, by Adolph Knopf; including detailed geologic and topographic maps.

Preliminary report on mineral deposits of Sitka region, by Adolph Knopf.

The headwater region of the Gulkana and Susitna rivers, with an account of the Chistochina and Valdez Creek placers, by F. H. Moffit, including geologic and topographic reconnaissance maps.

Geology and mineral resources of the southern part of Kenai Peninsula, by U. S. Grant and D. F. Higgins, including geologic reconnaissance maps.

The coal fields of the lower Matanuska Valley, by G. C. Martin.

Geology and mineral resources of the Fairbanks district, by L. M. Prindle and F. J. Katz; including detailed topographic and geologic maps.

The Fairbanks quadrangle, by L. M. Prindle; including geologic and topographic reconnaissance maps.

The Bonnifield region of the Tanana Valley, by S. R. Capps; including geologic and topographic reconnaissance maps.

The Koyukuk-Chandalar gold region, by A. G. Maddren; including geologic and topographic reconnaissance maps.

The Iditarod-Innoko region, by A. G. Maddren; including geologic and topographic reconnaissance maps.

Geology of the Nome and Grand Central quadrangles, by F. H. Moffit and Philip S. Smith; including detailed geologic map.

The water supply of Seward Peninsula, by F. F. Henshaw and P. S. Smith; including topographic reconnaissance map.

REPORT ON PROGRESS OF SURVEYS OF PUBLIC LANDS IN ALASKA DURING 1910.

By Alfred H. Brooks.

INTRODUCTION.

An item in the sundry civil act approved June 25, 1910, provided "for the survey of the lands in the United States in the District of Alaska, $100,000." In accordance with instructions, the Director of the Geological Survey, on June 25, 1910, submitted plans for the surveys authorized by this item to the Secretary through the Commissioner of the General Land Office. These were approved by the Commissioner and by the Secretary on June 29. In a letter dated June 29 the Director instructed the geologist in charge of the division of Alaskan mineral resources to put the plans into execution.

OUTLINE OF PLANS.

The approved plans authorized the following surveys:

1. The astronomic determination of the latitude, longitude, and azimuth in the vicinity of the initial point of the proposed surveys near Fairbanks.

2. Time permitting, the astronomic determination of latitude, longitude, and azimuth at another point near the mouth of Tanana River which might be used as a reference point for future land surveys in this district.

3. The inauguration of a triangulation system in the vicinity of Fairbanks by which the accurate location of land lines and corners could be determined and which could also be developed so as to permit extensions into other areas where subdivisional surveys are needed.

4. The extension of a base and meridian from the initial point near Fairbanks.

5. The surveying of such township exteriors as were deemed advisable.

6. Time permitting, the subdivision of these townships.

7. The making of reconnaissances in the Copper River, Seward, and Matanuska regions for the sake of obtaining information on which to plan surveys in these provinces.

METHODS OF SURVEY.

The surveys provided for three classes of work—astronomic determination of positions, triangulation, and linear measurement.

The astronomic work was performed by the Coast and Geodetic Survey in accordance with its long-established standards and methods.

The triangulation, including measurement of base, was executed in accordance with the standards and methods of the Geological Survey.

The approved plans authorized the making of linear measurements either by stadia or with steel tape, depending on the physical character of the country to be surveyed. In either method the standard set for accuracy was to be maintained. In practice it was found that the lines actually run could be best measured by steel tape. There is no doubt, however, that under favorable conditions the stadia is applicable and advisable.

The plans approved also provided that the township corners should be tied to triangulation points so far as practical, thus giving an entirely independent check on the line work. It is worthy of note that this is the first time that any subdivisional surveys made by the United States Government have been checked by triangulation. The United States is the only country in the world which does not use geodetic methods in making its land surveys.

Soon after reaching the field the engineers satisfied themselves that in this latitude and under existing climatic conditions the old method of controlling the azimuth of linear surveys by means of solar transit was not practical for the following reasons:

1. Observations on Polaris through the small telescopes of the transits are impracticable before the 10th of August.

2. The altitude of Polaris, about 65° in this latitude, increases the difficulty of accurate observations.

3. The sun's path in this high latitude is such that solar observations for a good part of the day are very unreliable.

4. During the season of 1910, owing to climatic conditions, the sun was visible for solar observations only about one-fifth of the time.

Accordingly the lines were run as plain transit lines on the basis of the azimuth determination made at the astronomic station and transferred to the different lines by the triangulation system. This not only saved time but yielded results of a higher degree of accuracy than could be obtained in this latitude by the old method.

PERSONNEL.

As provided for in the plans submitted, the Superintendent of the Coast and Geodetic Survey detailed the necessary engineers to make the latitude, longitude, and azimuth determinations at Fairbanks and at the mouth of the Tanana.

R. H. Sargent, topographer, was put in charge of the field parties at Fairbanks. C. L. Nelson, W. N. Vance, and S. G. Lunde, topographers, were detailed to assist Mr. Sargent. In addition to these four engineers, who were detailed from the permanent staff of the Geological Survey, four chainmen and one recorder accompanied the party from Seattle. At Fairbanks 21 other men were engaged as rodmen, axmen, packers, cooks, etc.

The personnel of the two line parties and the triangulation party were as follows:

Line parties:
- 1 engineer in charge.
- 4 chainmen.
- 2 flagmen.
- 3 axmen.
- 1 cook.
- 1 teamster.

Triangulation party:
- 1 engineer in charge.
- 1 axman.
- 1 packer.
- 1 cook.
- 1 recorder.

Mr. Sargent was directed, after inaugurating the work at Fairbanks, to proceed by trail to Valdez and make the necessary investigations along this route to procure information needed for planning future work in this field.

Mr. Brooks undertook similar investigations in the northeastern part of Kenai Peninsula and in the Matanuska region.

DISTRIBUTION OF TIME OF FIELD PARTIES.

To attain efficient and economic administration, the Fairbanks parties should have gone inland over the winter trail; and had this been done, some field work might have been begun by the 1st of May. As a matter of fact, the money was not available until July 1, and therefore the parties could not leave for the field until that date. Mr. Sargent, Mr. Nelson, and Mr. Lunde, with four chainmen and one recorder, sailed from Seattle on July 5 and arrived at Fairbanks, by way of the White Pass route, on July 22. The field parties were at once organized and the measurement of a base line was begun the following day. Mr. Vance, whose departure from Seattle had been unavoidably delayed, reached Fairbanks on August 8. On August 9 line work was begun by two parties and continued until about October 7. Meanwhile the third party had been engaged in triangulation. Topographic surveys along the surveyed lines was begun about October 10 and continued until about October 20, when stormy weather necessitated the disbanding of the field parties.

Mr. Sargent organized the work at Fairbanks and continued with the parties until September 15. He then spent 14 days in investigating conditions which would affect future surveys in the region traversed by the Valdez-Fairbanks trail.

Mr. Brooks was detained in Washington by office duties until August 3. He sailed from Seattle on August 8 and arrived at Seward on August 18. Continuing his journey, he arrived at Knik on August 20. From August 21 until September 9 he spent in the Knik Arm and Matanuska region. Returning, he sailed from Seward for Seattle on September 17.

The combined time of Mr. Vance and Mr. Lunde, chiefs of the line parties, from the dates of their leaving the office to their return, was 281 days, a detailed account of which follows:

	Days.
Travel to field and return	113
Measuring triangulation base line and constructing astronomic stations	14
Line work	85
Topographic surveying	21
Field computations and office work	5
Outfitting	3
Stormy weather	14½
Moving camp	12½
Days observed as Sundays	13
	281

Upon Mr. Sargent's departure, Mr. Nelson was left in charge of the field work and thereafter devoted the larger part of his time to administrative duties. He was employed 43 days on field work in connection with the triangulation, 48 days on supervision and computation, 50 days in traveling, and 10 days in outfitting.

RESULTS.

Astronomic determinations.—An astronomic determination of latitude, longitude, and azimuth was made at a station near Fairbanks by the Coast and Geodetic Survey. A similar determination was made at Tanana, a settlement on the west bank of the Yukon, at the mouth of Tanana River. This was in accordance with the approved plans and an agreement made between the Secretary of the Interior and the Secretary of Commerce and Labor under date of July 5, 1910. The Superintendent of the Coast and Geodetic Survey transmitted the results of the final computations of these observations on February 6, 1911.

Triangulation.—A base line was measured and a system of triangulation inaugurated, the geodetic position of which was based on the astronomic observations. This triangulation not only checked the line surveys but can also be extended into adjacent parts of the Tanana Valley to provide points from which land surveys of important areas may be executed in the future. By this means the projection of long standard parallels and guide meridians through areas of no commercial importance will be avoided.

The primary triangulation stations are marked by bronze tablets, furnished by the General Land Office, firmly set in concrete or solid rock. Preparatory to the future expansion of the triangulation system six signals have been constructed on prominent hills in the Tanana Valley.

Summary of triangulation.

Base line measured	feet	13,876.674
Primary stations occupied		12
Secondary stations occupied		15
Points intersected		3
Signals constructed		6

Line work.—The line work consisted chiefly of extending base and meridian lines and the survey of township exteriors. Some section lines and a few meanders were also run. The geodetic position of the initial point was determined by triangulation. It seemed desirable not to attempt the sectionizing of the townships until the matter of the rights of the homesteaders had been settled.

Summary of line surveys.

	Miles.
Principal meridians	23.7
Base line	18
Township exteriors	43.7
Section lines	11.8
Meanders	11.7
	108.9

It was impossible to ship iron posts to Fairbanks in time to make them available for the season's work. Wooden posts were therefore set, properly inscribed and witnessed in accordance with the regulations of the General Land Office.

The number of corners set was as follows:

Initial point	1
Township corners	7
Standard township corners	3
Closing township corners	3
Section corners	76
Quarter corners	88
Meander corners	8
Witness corners	8

COST OF SURVEYS.

The expenditures for public-land surveys in Alaska to and including May 15, 1911, were as follows:

Geological Survey	$32.591.02
Coast and Geodetic Survey	2,013.06

The estimated liabilities are $528.19. The total cost of these surveys is therefore $35,132.27.

OFFICE WORK.

Mr. Nelson was furloughed on January 12, thus leaving Messrs. Sargent, Vance, and Lunde to work upon the notes and plats, The following data were transmitted to the Commissioner of the General Land Office on May 15, 1911: Notes and plats of land lines; results of astronomic observations; notes and results of triangulation base measurements, all corrections being computed; notes and results of the triangulation with least-square adjustment applied.

RECOMMENDATION FOR CONTINUATION OF SURVEYS.

If the policy established last year of surveying the arable lands, especially those which are now being taken up as homesteads, is to be continued, there are three general provinces in which work should be done—the Tanana Valley, the Cook Inlet region, and the Copper River valley.

In the Tanana Valley the subdivision of townships whose exteriors have already been surveyed should be completed and the surveys should be extended by means of the triangulation system into adjacent areas where homesteads have been taken up.

In the Copper River region the positions of the base and meridian lines already surveyed should be astronomically determined, so that the township surveys in this field can be accurately tied to other Alaskan surveys. To obtain an accurate datum for elevations, a line of primary levels should be run from Cordova to Fairbanks. A triangulation should be carried up the Chitina Valley, so as to provide a tie point for subdivisional surveys, which will soon be needed in this field because of the demands of settlers now being attracted by the railway that is under construction. Plans should be made to subdivide the arable lands in the Chitina Valley.

In the Cook Inlet region it seems desirable to subdivide the flats and floors of tributary valleys adjacent to Resurrection Bay. These surveys should be tied to triangulation points of the Coast and Geodetic Survey. It is also desirable to begin township surveys at Knik and at Seward, covering the arable lands of the vicinity. These surveys should also be tied to the Coast and Geodetic Survey triangulation.

If the coal fields are to be subdivided, work should be begun in the Bering River, Matanuska, and Nenana fields. The surveys in the Bering River field should be tied by triangulation to points of known position on the coast. The Matanuska surveys should be tied by triangulation to Coast Survey points on Knik Arm. The Nenana field can readily be reached by extending the Fairbanks triangulation southward.

It is furthermore recommended that authority be obtained, by legislation if necessary, to permit the boundaries of bona fide homesteads to stand as recorded. All the members of the Geological Survey who are conversant with the conditions are agreed that if the rights to lands as recorded by homesteaders are not recognized grave injustice may be done.

THE MINING INDUSTRY IN 1910.

By Alfred H. Brooks.

INTRODUCTION.

The gold and copper lode-mining industry of Alaska made considerable progress in 1910, not so much in output as in the amount of dead work accomplished. On the other hand, there was a falling off in the production of the placer mines and an absolute stagnation in all enterprises depending on the opening of the coal fields.

As in previous years, the lack of cheap fuel is the one great hindrance to the advancement of the mining industry in Alaska. So long as the Pacific seaboard of Alaska and the adjacent portions of the inland region have to depend on expensive coal brought from British Columbia, Japan, and Washington, so long will the industries of the Territory suffer. With coal at $8 to $20 a ton along the Pacific seaboard of Alaska, even mines located at tidewater are at great economic disadvantage. Under such conditions only the richest and largest ore bodies can be mined at a profit. Moreover, railway construction will be active only when there is an assured tonnage from the coal fields and when cheap fuel for operating is available.

The inadequacy of the mineral-land laws which apply to placer claims continues to hamper the mining industry by discouraging the bona fide miner and prospector. This condition, while ever present, is emphasized when a new district is discovered and a few men, often mere speculators and not miners, can preempt large tracts of land and hold them for a year and sometimes nearly two years without doing any development work.

In spite of the decreased gold production and the handicap because of the delay in opening the coal fields, considerable advance was made in the mining industry. Copper mining was prosperous and much development work was done on the copper deposits. More has been accomplished than in any previous year in the development of auriferous lodes. Much work was also done toward installing large mining plants for working low-grade placer deposits. The decrease in the value of the gold production is entirely chargeable to the falling off in the output from the placer mines of Fairbanks, Seward Peninsula, and some of the smaller placer districts. Except in these camps and the coal fields, the output from all the mining districts increased.

The value of the total mineral production in 1910 is estimated at $16,925,178; in 1909 it was $21,141,019. In the following table the sources of this wealth, as well as a comparison with the previous year, are presented. The statistics for gold and silver output are not yet completed and may be subject to change, but the figures for the other mineral products are presented with more confidence as to their accuracy.

It should be noted that the apparent increase in silver production in 1910 as compared with 1909 is due largely to the fact that in the past the silver content of the placer gold has been estimated too low. This is due to the fact that the placer-gold producers make no returns of the silver content of their gold output. The placer silver, which occurs as an impurity in the gold, can be arrived at only by a computation based on the purity of the gold. The accumulation of data on the composition of the placer gold from the several districts during the last six years has made it possible to compute the silver percentage more accurately and has shown that in the statistics published in the past the estimate for placer silver is too low.

In the table the outputs of marble, tin, gypsum, etc., are combined because a separate listing might reveal the production of individual properties.

Mineral production of Alaska, 1909–10.

	1909		1910 [a]		Increase (+) or decrease (—).	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Gold...............ounces..	987,416.76	$20,411,716	781,836.75	$16,162,000	—205,580.01	—$4,249,716
Silver...............do....	147,950.00	76,934	169,418.00	91,485	+ 21,486.00	+ 14,551
Copper............pounds..	4,124,705.00	536,211	4,241,689.00	538,695	+116,984.00	+ 2,484
Coal............short tons..	2,800.00	12,300	1,400.00	13,600	— 1,400.00	+ 1,300
Marble, gypsum, tin, mineral water, and lead......	....	103,858	....	119,398	....	+ 15,540
	....	21,141,019	....	16,925,178	....	— 4,215,841

[a] Preliminary estimates.

NOTE.—In the above table copper is valued at 13 cents a pound for 1909 and 12.7 cents for 1910; silver at 52 cents an ounce for 1909 and 54 cents for 1910.

Mining began in Alaska in 1880, but for many years no very accurate records of mineral output were kept. Since 1905, however, fairly reliable statistics of mineral production are available. These data are summarized in the following table, both by years and by substances:

Value of total mineral production of Alaska, 1880–1910.

By years.				By substances.	
1880–1890	$4,686,714	1901	$7,007,398	Gold	$178,797,171
1891	916,920	1902	8,400,693	Silver (commercial value)	1,286,687
1892	1,096,000	1903	8,941,614	Copper	5,338,709
1893	1,048,570	1904	9,567,535	Coal	336,789
1894	1,305,257	1905	16,478,142	Marble, gypsum, tin, etc	552,014
1895	2,386,722	1906	23,375,008		186,311,370
1896	2,980,087	1907	20,847,055		
1897	2,538,241	1908	20,142,272		
1898	2,585,575	1909	21,141,019		
1899	5,703,076	1910	[a] 16,925,178		
1900	8,238,294				
			186,311,370		

[a] Preliminary estimate.

TRANSPORTATION.

The nondevelopment of the coal fields has put the railways at a double disadvantage. In the first place, those of the Pacific slope region are paying $11 to $12 a ton for coal used in operating, when high-grade coal should cost them only from $2.50 to $3.50. Moreover, the imported coal is of an inferior quality compared with the native fuels. In the second place, the coal tonnage needed to help support the railways is nonexistent. In spite of these handicaps, the backers of some of the railway projects have shown commendable enterprise in either continuing construction work or preparing for it.

The most important event of the year in the development of transportation routes was the extension of the Copper River & Northwestern Railway to about mile 150. As this report goes to press telegraphic dispatches announce that this railway has been completed to Kennicott, a distance of 195 miles from the coast at Cordova. This affords an outlet for the copper ores of the Kotsina-Chitina district and renders the Nizina placer district readily accessible. It also both shortens the winter sled route to Fairbanks and does away with the necessity of crossing the high coastal barrier. It will also decrease the cost of transportation to the Valdez Creek and Chistochina placer districts and render the copper belt of upper Nabesna and White rivers more accessible. With the changing of the trail from Chitina to Fairbanks into a wagon road, which is now being accomplished by the Alaska Road Commission as fast as funds available permit, an overland summer route to the Tanana camps will be opened. Take it all in all, this is the most important advance made in the history of Alaska transportation since steamboat service was established on the Yukon about half a century ago.

The Alaska Northern Railway did no new construction work because of the coal-land situation, but it maintained communication over its 71 miles of track which connects Seward, the coastal terminal, with the head of Turnagain Arm. By the use of small launches a route of communication with Knik and points on Susitna River was thus established, which is competitive with the older route from Cook Inlet. Some location surveys were also made beyond the end of the road. This railway, when completed, will lead to the development of the Matanuska coal field and the Willow Creek lode district, as well as other mining districts of the Susitna basin, besides making accessible extensive areas of arable land.

Most of the other railway projects appear to have lain dormant awaiting the settlement of the coal-land question. The completed railways, such as the White Pass, Tanana Valley, and Seward Peninsula, were operated but need no special mention. At the close of 1910 the aggregate length of all Alaska railways was about 420 miles, compared with 371.4 miles at the close of 1909. This mileage is distributed among nine different railways, from 5 to 196 miles in length.

Among the important work accomplished by the Alaska Road Commission, in addition to the continuation of work on the Valdez-Fairbanks wagon road, already referred to, was the preparation for the establishment of a winter trail from the inland terminus of the Alaska Northern Railway to the Innoko-Iditarod region. This will serve the placer miners of the Susitna basin, the Kuskokwim, and the Innoko-Iditarod and will shorten the winter mail route from the Pacific seaboard to Nome by about 300 miles. The commission also built or improved many other roads and trails in different parts of the Territory.

METAL MINING.

INTRODUCTION.

In 1910 about one-quarter of the gold production came from lode mines and three-quarters from placers. It is a significant fact that in 1909 only one-fifth of the gold came from lode mines. The ratio of lode production to placer production has varied considerably during the 30 years that mining has been carried on. In the first two or three years the gold output was almost all from placers. With the opening of the lode mines of the Juneau belt the lode production became larger than the placer, the ratio in 1894 being about 2 to 1. Five years later, when the Nome placers were developed, the ratio of lode to placer output decreased to about 1 to 3. After this the percentage of lode production gradually decreased until 1910, when it began to rise. A further increase in the ratio of gold lode to placer output is to be expected. In the following table, which is based on the preliminary estimates, the metal production has been distributed as to source:

Sources of gold, silver, and copper in Alaska, 1910.

	Tonnage.	Gold.		Silver.		Copper.	
		Ounces.	Value.	Ounces.	Value.	Pounds.	Value.
Siliceous ores	1,400,000	199,595.25	$4,126,000	31,450	$16,983		
Copper ores	39,000	1,741.50	36,000	26,300	14,202	4,241,689	$538,695
Placers		580,500.00	12,000,000	111,668	60,300		
		781,836.75	16,162,000	169,418	91,485	4,241,689	538,695

In the following table the production of gold, silver, and copper is given by years. The fluctuations in the gold output are chargeable to the discovery of bonanza placer deposits, which at different times in the past have yielded large quantities of gold. This form of mining, while still continuing, will probably in the future contribute a decreasing percentage of the gold production, and as a result there will be less marked fluctuations in the annual output.

Production of gold, silver, and copper in Alaska, 1880–1910.

Year.	Gold.		Silver.		Copper.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Commercial value.	Quantity (pounds).	Value.
1880	968	$20,000			3,933	$826
1881	1,935	40,000				
1882	7,256	150,000				
1883	14,566	301,000				
1884	9,728	201,000	10,320	$11,146		
1885	14,513	300,000				
1886	21,575	446,000				
1887	32,653	675,000				
1888	41,119	850,000	2,320	2,181		
1889	43,538	900,000	8,000	7,490		
1890	36,862	762,000	7,500	6,071		
1891	43,538	900,000	8,000	7,920		
1892	52,245	1,080,000	8,000	7,000		
1893	50,213	1,033,000	8,400	6,570		
1894	61,927	1,282,000	22,261	14,257		
1895	112,642	2,328,500	67,200	44,222		
1896	138,401	2,861,000	145,300	99,087		
1897	118,011	2,439,500	116,400	70,741		
1898	121,760	2,517,000	92,400	54,575		
1899	270,997	5,602,000	140,100	84,276		
1900	395,030	8,166,000	73,300	45,494		
1901	335,369	6,932,700	47,900	28,598	250,000	40,000
1902	400,709	8,283,400	92,000	48,590	360,000	41,400
1903	420,069	8,683,600	143,600	77,843	1,200,000	156,000
1904	443,115	9,160,400	198,700	114,934	2,043,586	275,676
1905	756,101	15,630,000	132,174	80,165	4,805,236	749,617
1906	1,066,030	22,036,794	203,500	136,345	5,871,811	1,133,260
1907	936,043	19,349,743	149,784	98,857	6,308,786	1,261,757
1908	933,290	19,292,818	135,672	71,906	4,585,362	605,267
1909	987,417	20,411,716	147,950	76,934	4,124,705	536,211
1910[a]	781,837	16,162,000	169,418	91,485	4,241,689	538,695
	8,411,467	178,789,171	2,130,199	1,286,678	33,795,108	5,338,709

[a] Preliminary estimate.

In the following table the total gold production is distributed according to districts, so far as the information at hand will permit. The error in distribution is believed to be less than 15 per cent, and it is hoped in future statements to eliminate it altogether. The production from the Pacific coast belt is for the most part from the lode mines of southeastern Alaska but includes also a small placer output, as well as the production from a lode mine on Unga Island. The gold credited to the Cook Inlet and Copper River region is, aside from the output of some small quartz mines in the Susitna basin and on Kenai Peninsula, all from placers and includes the yield of the Nizina, Chistochina, Sunrise, Yentna, and Valdez Creek districts.

The gold output of Seward Peninsula and the Yukon basin [1] is nearly all from placers, though there was a small output from the lode prospects of the Fairbanks districts, at least one of which can be classed as a mine.

Value of gold production of Alaska, with approximate distribution, 1880–1910.

Year.	Pacific coast belt.	Copper River and Cook Inlet region.	Yukon basin.	Seward Peninsula and northwestern Alaska.	Total.
1880	$20,000				$20,000
1881	40,000				40,000
1882	150,000				150,000
1883	300,000		$1,000		301,000
1884	200,000		1,000		201,000
1885	275,000		25,000		300,000
1886	416,000		30,000		446,000
1887	645,000		30,000		675,000
1888	815,000		35,000		850,000
1889	860,000		40,000		900,000
1890	712,000		50,000		762,000
1891	800,000		100,000		900,000
1892	970,000		110,000		1,080,000
1893	833,000		200,000		1,033,000
1894	882,000		400,000		1,282,000
1895	1,569,500	$50,000	709,000		2,328,500
1896	1,941,000	120,000	800,000		2,861,000
1897	1,799,500	175,000	450,000	$15,000	2,439,500
1898	1,892,000	150,000	400,000	75,000	2,517,000
1899	2,152,000	150,000	500,000	2,800,000	5,602,000
1900	2,606,000	160,000	650,000	4,750,000	8,166,000
1901	2,072,000	180,000	550,000	4,130,700	6,932,700
1902	2,546,600	375,000	800,000	4,561,800	8,283,400
1903	2,843,000	375,000	1,000,000	4,465,600	8,683,600
1904	3,195,800	500,000	1,300,000	4,164,600	9,160,400
1905	3,430,000	500,000	6,900,000	4,800,000	15,630,000
1906	3,454,794	332,000	10,750,000	7,500,000	22,036,704
1907	2,891,743	275,000	9,183,000	7,000,000	19,349,743
1908	3,448,318	401,500	10,323,000	5,120,000	19,292,818
1909	4,264,716	265,000	[a] 11,580,000	4,302,000	20,411,716
1910	4,237,000	350,000	[a] 8,045,000	3,530,000	16,162,000
	52,261,971	4,358,500	64,962,000	57,214,700	178,797,171

[a] Includes a small production from the Kuskokwim.

LODES.

DEVELOPMENT AND PRODUCTION.

The total gold production from the auriferous lode mines of Alaska which have been productive since 1882 is estimated to be 2,346,635 fine ounces, valued at $48,602,775. These mines have also produced 1,001,241 fine ounces of silver, with a commercial value of $611,808.

[1] This refers, of course, only to the Alaskan parts of the Yukon basin and does not include the production of the Klondike and other Canadian camps.

The total copper production up to the close of 1910 was 33,775,108 pounds, valued at $5,338,709. Tin mining began in the York region in 1902, since which time it has been carried on spasmodically. The value of the total tin product, which has come chiefly from the placers, up to the close of 1910 is $139,639. There has also been some recovery of lead from ores valuable chiefly for other metals.

While the output of the auriferous lodes in 1910 was about the same as that of 1909, marked advances were made in installing mining plants and in prospecting. As a result it is most probable that the lode-gold output in 1911 will be greater than that of 1910 and that the production will increase very much in the next two or three years.

Alaska's auriferous lodes are estimated to have produced during the year 199,595 fine ounces of gold, valued at $4,126,000, as compared with an output of 199,181 fine ounces, valued at $4,117,440, in 1909. The output of the Juneau district was somewhat less than in the previous year, but this is only a temporary setback, for the large amount of development accomplished assures a larger output in 1911. The increased output must be credited to the Sitka, Port Valdez, and other smaller districts. Noteworthy advances in prospecting auriferous lodes were made in the Prince William Sound region, Kenai Peninsula, at Willow Creek, and in the Fairbanks district.

There were 14 productive gold-lode mines in operation in Alaska in 1910, two more than in 1909. Work was also done on more than 50 gold prospects, a few of which produced some gold as an incident to the development work. Of the producing mines six were in the Juneau district.

It is estimated that these mines had an output of 1,400,000 tons of ore, as compared with 1,496,361 tons, the total output for 1909. The decrease in tonnage with an increase in value of gold output indicates the relatively larger percentage of the total made by mines exploiting high-grade ores. In 1909 the average value of gold-silver contents for all the ores mined was $2.72; the average in 1910 is estimated to have been $2.85.

There were six productive copper mines in 1910, as compared with seven in 1909. In addition to these there were several properties which produced some copper incidental to development work. The certainty that the Kennicott-Bonanza mine will be shipping ore in 1911 assures a very large increase in the copper production. Further more, other Alaska copper mines are making preparations to increase their output, and several properties which have not yet been productive will probably begin shipping some ore in 1911. All of this assures a rapid expansion of Alaska's copper-mining industry.

The total copper production in 1910 was 4,241,689 pounds, valued at $538,695, compared with 4,124,705 pounds, valued at $536,211, in 1909. About $36,000 worth of gold and $14,202 worth of silver was recovered from the copper ores. It is estimated that in 1910 about 39,000 short tons of copper ore was hoisted, as compared with 34,669 tons in 1909. The average copper content of the ore was about 5.4 per cent and the gold-silver values about $1.29 to the ton.

SUMMARY OF LODE MINING BY LOCALITIES.

PACIFIC COAST REGION.

Except for a small production at Fairbanks, all of the auriferous-lode gold came from mines situated on the Pacific seaboard or in the drainage basins tributary to it. Lode mining, especially that of the Treadwell group of mines, in the Juneau district, continues to overshadow all other enterprises of this kind. Mr. Knopf on pages 94–111 summarizes the mining developments of the year in southeastern Alaska.

Kotsina-Chitina district.—The most important event of the year in the Kotsina-Chitina copper district was the extension of the Copper River & Northwestern Railway, already referred to on page 23. As this report goes to press (April, 1911) a telegraphic dispatch from Cordova announces that the first train load of copper ore has been shipped to the coast from the Kennicott-Bonanza mine. This is one of the most important events in the history of Alaska's mining industry, as it assures the opening of a region which promises to become an important producer of copper.

The Kennicott-Bonanza is now fully equipped to ship ore, of which a large quantity of extraordinary richness has been blocked out. The deepest workings are from 150 to 160 feet below the surface. During 1910 the most important development was the construction of ore bins and a concentrator at the railway terminal, which is connected with the mine by an aerial tram 15,000 feet in length.

The assurance of a railway has led to much prospecting of other claims in the Kotsina-Chitina district, detailed information in regard to which is, however, lacking at this writing. It is reported that the development work done on the Mother Lode group of claims, which lie on the McCarty Creek side of the Bonanza divide, has opened some very promising ore bodies. The work accomplished in the Kotsina region, at the west end of the copper belt, is also reported to have developed some good ore bodies. Up to the present time the aggregate amount of rock work accomplished, outside of the Kennicott-Bonanza, has been very little, but now that quick and comparatively cheap transportation is assured, more systematic development will undoubtedly be undertaken.

Lower Copper River basin.—The Bremner and Tiekel regions of the lower Copper River basin have long been known to carry auriferous gravels, some of which have been mined in a small way. In 1910 some auriferous quartz veins were found in this district. So far as known, their geologic occurrence is similar to that of the veins of Port Valdez. Interest in gold-bearing lodes was revived in the McKinley Lake region in 1910 by some new discoveries. These discoveries are a few miles north of Algonik, a station on the Copper River & Northwestern Railway about 22 miles from Cordova.

Prince William Sound.—The most important event of the year in the Prince William Sound region was the development of an auriferous lode mining district on Port Valdez. Though some of the gravels of this region have long been known to be auriferous, little search was made for lode deposits until 1909 and no commercial ore bodies were developed until 1910. The most important prospects thus far discovered lie in an area bounded on the east by Valdez Glaciers, on the south by Port Valdez, on the west by Shoup Bay and Shoup Glacier, and on the north by a less well defined line lying 2 to 5 miles from tidewater. Some prospects have also been located on the south side of Port Valdez. Within this area more than 200 lode claims have been staked, most of them during 1910. As during all other periods of mining excitement, only a small fraction of these claims can be expected to contain commercial ore bodies. The facts that one mine has been opened, that several other prospects have been sufficiently developed to give promise of carrying commercial ores, and that auriferous mineralization is widely distributed augur well for the future of the district.

The Cliff mine, the only property which has been put on a productive basis, is located near the eastern entrance to Shoup Bay, about 8 miles west of the town of Valdez. The claim was staked in 1909 (?), development work began in July, 1909, and a 3-stamp mill, said to have a capacity of 30 tons a day, was installed in April, 1910. As, however, up to the time of the writer's visit (August, 1910) only one concentrating table was in use, the mill had been run only two shifts (16 hours) each day. The mine was operated until December, when it was temporarily closed, but work was resumed in January, 1911.

The following notes are based on a hasty visit:

The country rock at the mine appears to be chiefly dark siliceous slate, in places graphitic and usually blocky. At the beach the strike is about east and west and the dip 20° to 30° N. The slate carries mica and is in places heavily charged with finely divided pyrite, which occurs in veinlets cutting the foliation and is also disseminated especially along the cleavage planes. There has been movement later than the pyrite, as is shown by slickensided surfaces about parallel to the cleavage.

The vein cuts across the foliation of phyllites with a strike of about N. 30° to 45° W., averaging about N. 35° W. It dips southwest at an angle of about 50° to 70° but has some rolls in it. The footwall is smooth and along it there is from half an inch to 3 inches of gouge which carries values. There seems to have been no movement along the hanging wall, but it is well defined. The vein varies in width from, say, an inch, where quartz may be entirely lacking, to 34 inches. The managers report that small swellings occur where the vein widens out to 3 and 4½ feet. The vein matter is in places entirely lacking, but the fissure is everywhere well defined. In one place in the upper tunnel a roll was encountered where a bulge in the footwall gave a reverse dip to the vein. On the whole, the strike of the vein is fairly uniform in direction, though the workings show minor swings of 5° to 10°. At the upper prospect tunnel, about 150 to 200 feet above the beach, what appears to be the same vein has a thickness of about a foot. So far as determined by the exposures, the vein is definitely recognizable for about 300 to 400 feet, but the managers stated that it has been traced by float throughout the length of the claim, and it is reported that the same vein has been found on the north side of the ridge, a distance of probably 3,000 feet from the mine.

The typical vein filling is a blue quartz carrying considerable finely disseminated pyrite and also apparently minute quantities of arsenopyrite and galena, but no detailed study of ore has been made. Visible free gold is found, especially in the upper workings, where there has been considerable oxidation. Free gold occurs, however, in the fresh, unaltered vein material, where it is clearly not the product of alteration. In places the ore shows a rough banding, and this type is reported to carry the highest values. Some of the vein material is crushed and some shows a suggestion of brecciation and recementation.

Much of the ore is very rich, and the average recovery of free gold is currently reported to be about $50 to the ton. The manager reports no noteworthy change in values between the upper and the lower workings. The concentrates are said to run about 7 per cent and to have a value of about $100 a ton in gold.

Oxidation of vein matter is very marked on the upper level and was observed on the lower level to a distance of about 100 feet from the entrance of the adit. Beyond 100 feet on the lower adit there was no evidence of oxidation. The superintendent, Ray Millard, stated to the writer that there was no diminution in free-gold values at depth. At the same time the richest specimens of free gold seem to have been taken from the upper part of the mine. Values of $1.50 to $6 are reported in the hanging-wall rock, in which many quartz stringers were observed extending a distance of a foot or more from the vein. In the upper adit the vein matter is absent from the last 50 feet, but the fissure is traceable. It is in this part of the mine that the roll occurs.

There are two adit tunnels (which are connected by raises) 54 feet apart and one intermediate drift. Plans are made for sinking on the vein in the lower tunnel. There is also a prospecting tunnel which is 150 to 200 feet above the beach. The lower adit is about 200 feet long. According to the manager, a winze has been sunk to a depth of 50 feet below the lower adit since the writer's visit. At this depth the ore body seems to maintain itself and there are reported to be no notable changes in gold tenor.

No exact information is available regarding the many other properties which have been more or less prospected. Along the shores of Port Valdez, near the Cliff mine, are a number of veins, some of which have been developed by adit tunnels, but these were not examined by the writer. At the Imperial an adit has been driven along the vein for a hundred feet, and since the writer's visit an air compressor has been installed. A 3-stamp mill has also been erected near this point and probably on this property. In the fall of 1910 prospecting was being pushed on six or seven properties located on Mineral Creek. Of these the Williams-Gentzler property, about 4½ miles from the beach, is said to be one of the most promising. Here a well-defined 18-inch quartz vein carrying high gold values is reported. A wagon road has been completed from Valdez to Mineral Creek and up that stream about 4 miles.

There has also been considerable gold-lode prospecting in other parts of Prince William Sound. Encouraging results are reported from Jackpot Bay and from McClure Bay, both on the west side of the sound.

In the aggregate there was considerable work done on the copper lodes of Prince William Sound, though the low price of copper rather discouraged any except the strong companies from putting their properties on a shipping basis. Work was continued on the properties on Landlocked and Galena bays, though so far as known they made no shipments.

The Glacial Island Copper Co. is said to have opened a body of high-grade chalcopyrite ore by a tunnel 170 feet in length. The vein is said to be 4 feet wide and to be exposed 150 feet above the tunnel. A small bunker has been built and the managers report that some shipments will be made in 1911.

At the Beatson-Bonanza mine, on Latouche Island, ore bunkers having a capacity of 1,500 tons were built and a small water-power plant installed. A diamond drill is being used for prospecting. Ore shipments have continued throughout the year. A compressor plant with air drills has been installed on the property of the Seattle Alaska Copper Co. near Big Bay. The managers report that a 10-stamp mill and concentrating table are to be installed to concentrate the lower-grade ores. At Ellamar a horseshoe-shaped cofferdam 400 feet in length and 20 feet above low tide is being completed. A steam pumping plant has been installed and shipments of ore were made in 1910.

Kenai Peninsula.—There was great activity in quartz prospecting on Kenai Peninsula in 1910, but this district was not studied by the Geological Survey. The following notes are gleaned from numerous sources. Of the many properties which were developed to some extent, those of Watson & Snow, now incorporated under the name Wanowski Gold Mining Co., near Moose Pass, showed the greatest results. On this property several hundred feet of underground work has been accomplished, work having been done on one large quartz vein and another small one, which are parallel. The larger vein is well defined, having been traced for about a mile. Plans have been formulated for erecting a stamp mill in 1911.

On False Creek the California-Alaska Mining Co. continued work on a gold-bearing quartz prospect, where an air compressor has been erected. Work was also continued on the Stevenson property, in the same neighborhood. Auriferous quartz veins have been staked at many other places in the Sunrise placer district, but these have been for the most part little developed, except for the annual assessment work. What appears to be a promising auriferous quartz vein was found north of Turnagain Arm, at the head of Crows Creek. This vein is reported to be 2 to 4½ feet in width, of which 12 to 14 inches carries very high gold values. It is said to have been traced for several hundred feet. The specimens from this lode seen by the writer showed free gold and iron and arsenopyrite, with a gangue of well-developed interlocking crystals of quartz.

It appears from the information at hand that the quartz veins of Kenai Peninsula are similar in their geologic relations to those of Prince William Sound. There is, however, more than one type of vein filling. One of the lodes in the Moose Pass district appears to be a mineralized dike and hence of a different type from the other deposits which have been opened. At the Cliff mine, in the Port Valdez district, the values are largely in free gold, while in the Kenai Peninsula veins more of the gold is combined with the pyrite. Further study of these deposits will have to be made before more definite comparisons can be made.

Willow Creek.—The lode-mining developments of the Willow Creek region, north of Cook Inlet, are described by Mr. Katz on pages 139–150. These occur along the marginal contact of the great mass of granite which forms the Talkeetna Mountains. Prospectors report the occurrence of metal-bearing lodes in other parts of this contact zone, but little is known about them and they are practically undeveloped. Such lodes are said to occur on the upper part of Granite Creek and on Little Willow Creek. On Iron Creek, a tributary of the

Susitna, a lode has been found which carries chalcopyrite and pyrite, with copper and gold values. This is reported to occur at the contact of slate and greenstone, not far from the outer margin of the granite mass.

Southwestern Alaska.—There are but few mining developments in southwestern Alaska. Prospecting continued on the copper deposits of the Iliamna region and some steps were taken to open an auriferous lode on Popof Island. About 15 men were employed at the Apollo mine, chiefly in development work, but some ore was taken out. Some prospecting of auriferous lodes was also done on Kodiak, Dry, and Afognak islands.

YUKON BASIN.

Although many lode claims have been staked in the Yukon basin, there was little actual prospecting in 1910 and no developments of importance except in the Fairbanks and Chandalar districts. The completion of a 10-stamp customs mill with full equipment at Chena in November, 1910, has stimulated auriferous-lode development. Most of the actual lode-gold production came from the smaller mill at Fairbanks, which was operated at intervals during the year. One arrastre was also operated a part of the summer season. At this writing complete returns are not available from all the lode-mining operations, but it is estimated that probably about 200 tons was milled, yielding about $20,000 in gold, besides the concentrates and some values in silver. Detailed notes in regard to all the properties are lacking. The following data are based in part on information collected by G. L. Parker, incidental to his investigations of the water supply of the Fairbanks district.

The most important developments were on the Free Gold mine of Rhodes & Hall, located near the head of Cleary Creek. A part of this property was worked under lease and a part by the owners. The main adit tunnel, which follows the ledge, is reported at the close of the year to have been driven over 630 feet, and a shaft has been sunk about 50 feet, together with a 90-foot crosscut. In this distance the ledge has been lost once or twice through pinching or faulting but has been picked up again. The ledge varies from a few inches up to 4 feet in width and has been traced on the surface for a distance of about 1,000 feet. The greatest depth of the workings below the outcrop of the lode is about 250 feet, and to this depth there is apparently no change in the character of the ore.

An adit tunnel has been driven for about 300 feet on the property of the Tanana Quartz & Hydraulic Co., whose ledge (so far as known about 10 inches wide) parallels that of the Free Gold and lies close to it. On the "Carlisle fraction," which is also close at hand, a shaft has been sunk about 50 feet and some crosscuts have been driven.

Some rich ore was milled from this property, which was chiefly picked up on the surface.

Work has been continued by the Tolovana Mining Co. on its claims, where an 85-foot adit tunnel was driven, and some rich ore was mined and milled at Fairbanks. No data are at hand regarding the thickness of the ledge. This company is preparing to erect a stamp mill. Work has been continued on the Jupiter-Mars property, in the same neighborhood, where a 70-foot adit tunnel and 50-foot crosscut have been completed. Some work was also done on another group of claims on Willow Creek by Hershberger, Beall & Phipps, in the course of which some rich ore was taken out. No data are at hand regarding the thickness of the veins.

No work was done on the property of the Rex Mining Co. (Butler & Petree) on Chatham Creek, because of litigation. The total development to date includes a 160-foot inclined shaft with several prospecting levels. The vein is reported to be 4 to 8 feet in width. The property of the Pioneer Co. has been leased and some prospecting was done. On the Soo claim (W. L. Spalding) a 125-foot adit tunnel has been driven and a shaft sunk to a depth of 30 feet. The vein is about 15 inches wide. Some ore milled from this property gave good returns. On the adjacent Waterbury claim a 55-foot shaft has been sunk to develop a 3-foot vein, which yields good values in gold. The ore taken from this property in the course of development was sent to the mill and a 200-foot crosscut was driven. Some rich ore was taken out of a claim on Wolf Creek by Horton & Solomon.

Some open cuts were made on a lode located on the divide between Wolf and Fairbanks creeks, which was discovered in 1909. This property is owned by Lawrence McCarty and Frank Lawson. Some rich ore was taken out and milled at Fairbanks. The thickness of the lode had not been determined at the time of Mr. Parker's visit in August. In July and August five ledges were discovered on Fairbanks Creek. These seem to follow two systems of fissuring, one paralleling the creek and one about at right angles to this direction. They carry gold, galena, and stibnite. On the Excelsior claim a 7-foot vein is reported, according to the mining press, carrying $10 to $20 in gold and $15 to $30 in silver to the ton. Another vein is chiefly galena, with reported gold values of $5. Some ore was shipped to Fairbanks from these properties. The development work seems to have consisted chiefly of open cuts.

Two lodes about 300 feet apart have been located by Louis Friederich on the divide between Vault and Dome creeks. The westerly one has a granite-dike hanging wall and varies, so far as the small amount of surface work admits of determination, from 20 inches to 3½ feet in width. The easterly vein, which has been traced for about 800 feet, is from 3½ to 8 feet wide. It has been crosscut by an adit tunnel.

Both veins carry gold values and several tons of ore have been milled. These veins contain considerable stibnite. Since Mr. Parker's visit these prospects have been further developed and others have been opened in the vicinity.

Among other prospects reported is a 3-foot vein called the Hidden Treasure, near the head of Little Eldorado Creek, developed by a 140-foot tunnel and carrying high gold values, and another in the same vicinity on which a 38-foot shaft has been sunk and which is said to be 5 feet wide. Some ore has been milled from these properties.

Some developments were made on the claims of Whitman & Murray at the junction of Skoogy and Twin creeks. Here there are two shafts, 40 to 50 feet deep, and about 400 feet of drifts and crosscuts. An arrastre was built in 1910, with which considerable ore was milled.

The above notes indicate that considerable advance was made in lode mining during the year. Most of the veins opened are small and carry high values. The developments on the Free Gold property indicate that some of the veins, at least, have a persistence which is encouraging. There is good reason to think that the geologic conditions are the same throughout that part of the Fairbanks district where lodes have been found. All this, together with the presence of the rich gold placers, favors the belief that workable lode deposits will be developed.

The development of auriferous quartz veins continued in the Chandalar district in 1910. Conditions of transportation were somewhat improved in this district by the completion of 90-odd miles of trail from Beaver, on the Yukon, to Old Caro. In spite of the immense cost of transportation, a small 3-stamp mill was erected on the Gold King claims, owned by T. S. Haynes and E. W. Griffin, on Big Creek. This mill was erected with only a very insecure foundation, because of the high cost of timber, the nearest being 18 miles distant. Some ore was put through this mill. The Alaska-Chandalar Mining Co. continued development work on its property on Squaw Creek, on which the lode is reported to be from 4½ to 8 feet wide and to carry high gold values. A 4-stamp mill has been delivered at Beaver, on the Yukon, for this company and will be sledded in during the winter of 1911–12. The men who are developing this remote district in the face of such serious obstacles, including difficulty of transportation and lack of timber and fuel, merit the highest praise and support.

GOLD PLACERS.

INTRODUCTION.

The value of the placer-gold production of Alaska for 1910 is estimated at $12,000,000, as compared with $16,212,000 in 1909. The difference between these two amounts is almost exactly the sum of the decreased production of the Seward Peninsula and Fairbanks placers in 1910 as compared with 1909. This, however, does not tell the whole story, for in 1910 the output of the Fortymile, Rampart, and Koyukuk was less than in the previous years, but this loss was more than made up by the increased output of the Innoko-Iditarod region, whose production was more than double that of 1909. There were also small increases in the output of the placer camps of the Pacific slope as compared with previous years.

Among the most encouraging features of the year's placer mining are the large increase in the gold production of the Innoko-Iditarod region, the discovery of a new auriferous district in the Squirrel River basin of northwestern Alaska (see pp. 306–319), and the continuation of activity in the installation of dredges in Seward Peninsula. On the other hand, the delay in installing plants to exploit the extensive deposits of auriferous gravels in the Fairbanks district, whose gold values are too low to permit profitable exploitation by present mining methods, has not been encouraging. A large annual production has been maintained in the Fairbanks district up to the present time by the output from bonanza placer deposits, but deposits of this character are being rapidly depleted, and unless steps are taken to mine the gravels of lower grade, the output of the camp must continue to decline. Some advance, however, was made in the Fairbanks district, where a small dredge was built and preparations were made to install several large dredges in 1911.

In the following table the approximate yardage of the total bulk of gravels mined in Alaska during the last three years is presented, together with the value of the gold recovered per cubic yard. While these estimates are little more than scientific guesses, they are certainly near enough to the truth to indicate the order of magnitude to which the true figures belong. The estimated quantity of gravel mined is intended to include only that which is passed through the sluice boxes. Obviously, in open-cut mining any overburden which may be removed by shoveling, mechanical means, or ground sluicing will not be included in these totals.

Estimate of total amount of gravel sluiced in Alaska placer mines and value per cubic yard of gold recovered, 1908–1910.

	Total quantity of gravel (cubic yards).	Value of gold recovered per cubic yard.
1908	3,500,000	$4.45
1909	4,020,000	4.00
1910	3,800,000	3.20

These figures clearly indicate the improvement in mining methods which each year permits the exploitation of gravels of lower gold tenor than in the preceding year. If figures for the earlier years of placer-mining operations were available, the decrease in average gold content would be still more striking. For example, it has been estimated that the average gold content of the gravels mined on Seward Peninsula during the nine years ending in 1906 was about $5.95 a cubic yard,[1] while gravels mined on the peninsula in 1908–1910 yielded an average of $2.85.

There is probably no better evidence of the future of the Alaska placer-mining industry than the above figures. Every reduction in cost of mining means the making available for profitable exploitation of more auriferous gravels. These gold values in the gravels mined are still more striking when compared with the average gold content of the gravels mined in the States. According to Waldemar Lindgren, the average gold recovery from all the placer mines in the States for the year 1909 was about 12 cents a cubic yard.

SUMMARY OF PLACER MINING BY LOCALITIES.

PACIFIC COAST REGION.

For the purposes of this discussion the Pacific coast region will be made to include not only the seaboard but all the drainage basins tributary to it, including the Copper and Susitna. The placers of this province are estimated to have had in 1910 an output valued at $425,000, as compared with $330,000 in 1909. This increase is to be credited to the small districts of the region, of which the Yentna is the largest producer.

Southeastern Alaska.—A little placer gold was mined during 1910 on Gold Creek, near Juneau, but the only important mining ventures in this part of Alaska are those of the Porcupine district, lying about 40 miles from tidewater, on Lynn Canal. The largest operations in this field were those of the Porcupine Gold Mining Co., which operated its hydraulic plant for a good part of the season. A high-line flume was completed and a bedrock drain was extended 2,000 feet in 1910. The Cahoon Creek Placer Mining Co., in the same district, accomplished much dead work, including the building of flumes. Its plant was completed in time to do considerable hydraulicking. In addition to these, there were some smaller operations in the district.

Beach mining.—Beach mining was continued at a number of localities scattered along the Pacific seaboard from Lituya Bay to Unga Island. A large part of the gold recovered in this way comes from the Yakataga beach placers. In the past the relatively small bulk of auriferous gravels contained in the beaches has discouraged all but individual operators, who, for the most part, use the rocker. During 1910, however, steps were taken to organize a company to mine some of these beach placers on a larger scale.

[1] Collier, A. J., and others, Gold placers of parts of Seward Peninsula: Bull. U. S. Geol. Survey No. 328 1908, p. 136.

Copper River region.—The placers of the Chistochina district are described by Mr. Moffit on pages 112–137. Two hydraulic plants were operated in the Nizina district, besides a number of smaller plants. The output, which can not be published because it might serve to indicate the production of individual operators, was nearly twice as large as that of 1909. With the completion of the Copper River & Northwestern Railway this district will become readily accessible and an increased gold production is to be expected.

Sunrise district.—The placer-mining industry of the Sunrise district, including the northern part of Kenai Peninsula, had a prosperous season. This is shown not so much in the actual gold production, which is still small, as in the fact that initial steps were taken on several of the creeks to undertake mining on a large scale. These enterprises include plans for installing dredges and also for systematically exploiting groups of creek or bench claims by hydraulic methods. It is well known that there are extensive deposits of auriferous gravels whose values are too low to permit profitable exploitation by open-cut and manual methods.

During 1910 there were some half a dozen hydraulic plants, large and small, in operation in this district. One of the largest of these is on Crow Creek, where the operations of the year consisted largely in removing the heavy overburden, which covers the gold-bearing gravels, by hydraulic methods. In addition to the hydraulic mines, 15 or 20 smaller operators made some gold output.

Susitna basin.—There are in the Susitna basin three productive placer districts—Willow Creek, described by Mr. Katz on pages 150–152; Valdez Creek, described by Mr. Moffit on pages 119–124; and the Yentna district. The Yentna had the most profitable season in its history. Here placer gold has been found in three distinct areas in a belt some 20 miles long, which embraces the foothills of the Alaska Range. The most southwesterly of these includes the placers which have been found on Nakochna River, near the mouth of Kellar Creek, and on Eagle and Independence creeks, which join Yentna River. Here only a small amount of mining has been done so far. A second gold-bearing area includes the placers of some of the tributaries of Lake Creek, which have been mined only on a small scale. The third and up to the present time the most important gold-bearing area in this district is that drained by Cache and Peters creeks. The Cache Creek Mining Co. completed the installation of a hydraulic plant in 1910 and did considerable mining. Another company carried on large operations on Nugget Creek. The success of these larger plants has encouraged the investigation of other properties with a view to introducing improved methods. It is estimated that about 200 men were engaged in mining and prospecting in the entire district.

MULCHATNA REGION.

Mulchatna River heads in an unsurveyed area northwest of Lake Clark and flows into Bristol Bay. Gold has long been known to occur in its drainage basin, and some promising prospects are reported to have been discovered in 1910. The region is rather difficult of access, involving either a canoe trip from Cook Inlet via Iliamna and Clark lakes, with numerous portages, or a long upstream boat trip from Bristol Bay. In 1910 a steamboat was built at Bristol Bay for use on the Mulchatna. There are said to have been between 25 and 50 prospectors in this district in 1910.

YUKON BASIN.

The value of the placer production of the Yukon basin, including the Innoko-Iditarod region, in 1910 is estimated at $8,020,000, as compared with $11,580,000 in 1909. This falling off is due largely to the decreased production of the Fairbanks district, the value of whose output was $6,100,000[1] in 1910 and $9,650,000 in 1909. The mining industry of the placer camps of the Yukon-Tanana region, including Fairbanks,[2] is described by Messrs. Ellsworth and Parker on pages 153–172 of this volume. Mr. Maddren describes the Innoko-Iditarod region on pages 236–270. It will therefore only be necessary here to refer to the remaining districts, which include those of the lower Yukon, the Chandalar, and the Koyukuk.

Mining continued in 1910 in a small way in the Gold Hill district, which is near the mouth of the Tanana. Nothing of importance was accomplished, except preparations for mining on a larger scale than had hitherto been attempted. In the Chandalar district only three placer claims were worked in 1910. Interest centered on lode prospecting, which is referred to on page 35. Accurate figures of the gold output of the Koyukuk in 1910 are lacking at this writing, but it certainly was much less than that of 1909. This was due to the fact that the output of 1909 was far above the normal, because of the output of one or two rich spots on Nolan Creek, which were quickly mined out. According to current reports, some rich gravels were found during the year on Sheep Creek. Of perhaps greater significance is the reported occurrence of gold placers on Old Man Creek, a southerly tributary of the middle Koyukuk. It is estimated that about 300 men were engaged in mining and prospecting on the Koyukuk in 1910.

KUSKOKWIM REGION.

The influx of population to the Innoko-Iditarod region has led to considerable prospecting in the adjacent parts of the Kuskokwim

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[1] This does not include gold to the amount of over half a million dollars from other districts which passed through the town of Fairbanks.

[2] Lode mining is described on pp. 33–35.

basin. A trading post and settlement named Georgetown has been established on the Kuskokwim, about 325 miles above the Lelenaw anchorage, the highest point on the river reached by ocean-going vessels of any considerable size, and about 450 miles from Goodnews Bay, the nearest good harbor on Kuskokwim Bay. Georgetown affords a supply point for the Kuskokwim, and as a result there has been considerable prospecting in this general region.

The streams joining the Kuskokwim from the north near Georgetown head in the Innoko-Iditarod region and are known to carry auriferous gravels, though these have not yet been productive. (See pp. 267–269.) Some gold has also been found on the Holiknuk, a tributary of the Chulitna, which flows into the Kuskokwim from the south 15 or 20 miles below Georgetown. Some placer mining was done in 1910 on Bear Creek, in the basin of Toluksak River, tributary to the Kuskokwim from the east about 20 miles above Bethel. The extent of these operations is not now known. In 1900 the discovery of placer gold in the Goodnews Bay region attracted a number of prospectors, but interest soon flagged and prospecting was abandoned. This region has again attracted prospectors, and it is reported that in 1910 some claims made a gold output. All these discoveries lie in what would be the southwesterly extension of the Innoko-Iditarod region, and this fact alone would appear to justify further prospecting.

NORTHWESTERN ALASKA.

The region here termed northwestern Alaska includes the Kobuk region, where a little placer mining was carried on in 1910 (see pp. 271–319); the Norton Bay region, where there was little or no productive mining; and Seward Peninsula, which is, in spite of its decreased output, still second only to Fairbanks in the value of its annual gold output.

The value of the gold production of Seward Peninsula in 1910 is estimated to be $3,500,000, as compared with $4,260,000 in 1909. In spite of the decreased output the mining industry, in view of the large amount of dead work accomplished, can be said to have had a prosperous year. Ten new dredges were installed, of which nine were operated for a part of the season, in addition to seven dredges built in previous years, which were also operated. About $1,400,000 worth of gold was mined during the winter season, and about $1,000,000 of this in the region immediately tributary to Nome. Of the total output, some $2,200,000 is to be credited to the Nome precinct, including the Solomon River region. The Fairhaven precinct probably made an output worth half a million dollars, and the Council precinct somewhat less. The rest of the gold is to be credited to the placer mines of the Kougarok and Port Clarence precincts.

As already stated, dredging was the important feature of the year's mining industry. Three dredges were installed in the region tributary to Nome, making five in all for this district, of which four were operated. Four dredges were operated in the Solomon basin, of which two were built in 1910. Two new dredges and three old ones were operated in the Council region, and one new one in the Casadepaga basin.

Details regarding the operations of all these dredges are not available at this writing. It appears, however, that the 16 dredges, including the nine new ones, some of which were only completed in time for a brief test, were operated from 10 to 130 days, each averaging 58 days. The daily capacity of these dredges varies from 1,000 to 5,000 cubic yards, and they are equipped with a total of about 2,500 horsepower. The buckets vary in capacity from 2½ to 9 cubic feet, though all but five of the dredges have buckets of 3½ cubic feet or less. Two are driven by electric power, generated at one plant; seven are equipped with steam power, of which four use coal, two crude oil, and one wood. The other dredges are equipped with gasoline engines. It is estimated that the 16 dredges operated handled between 1,200,000 and 1,500,000 cubic yards of gravel, and had they all been able to operate to their full capacity they should have handled at least twice as great a yardage. It is a significant fact that the estimated bulk of gravel handled by all other forms of placer mining on the peninsula in the year 1910 is roughly estimated to have totaled 600,000 to 800,000 cubic yards. Complete returns are not yet available regarding the gold output of the dredges, but it is estimated to have a value of about $800,000. It seems probable that the average working season should be 110 to 130 days instead of 90, as has been the case in the past. If this is true, the dredge production can be largely increased even without any additional machines. Plans have already been formulated for the building of three or four dredges in 1911. If this is accomplished and the existing plants all prove efficient, it is not impossible that the output of the dredges alone in Seward Peninsula may soon reach $2,000,000. There is hope, therefore, that the gold output of the peninsula in 1910 may be the minimum for some time to come. The profits on dredging could be increased if power were furnished from one or two central stations. A further reduction in costs would be made by centralizing the management and by building dredges of the same type with interchangeable parts.

There is no question that there is a large amount of gravel suitable for dredging on Seward Peninsula and that this form of mining is likely to increase very much. It is unfortunate that the legitimate and well-managed projects often have difficulty in procuring the necessary capital because of a number of conspicuous failures. A certain class of promoters apparently believe that it is unnecessary to determine the presence of gold values, the thickness of the gravels, and the distribution of ground ice before installing a dredge. This point of view is probably sometimes forced on the local managers by the nonresident stockholders, who are so desirous of quick returns that they are willing to do the prospecting after the dredge is constructed. There is probably no phase of placer mining which requires such careful study of conditions and prospecting of gravel by competent engineers as does that of dredging.

While dredging was the most important industry of the peninsula during 1910, other phases of mining were not neglected. The Pioneer Co. purchased the Miocene ditch and used the water on several properties in the Nome region. Hydraulic plants were also operated on Bangor and Boulder creeks. The season's operations in the Kougarok precinct were especially successful because there was more water available than in any previous season for several years. The Taylor Creek Ditch Co., the largest operator in this district, was engaged in hydraulicking some bench gravels on Kougarok River. The Fairhaven Ditch Co. also had a successful season in the northeastern part of the peninsula.

COAL AND OIL.

Practically nothing was done in the coal fields except a few patent surveys. Most of the small mines which have in the past furnished lignitic coal for local use were in 1910 closed until the matter of granting patents should be finally decided. On the other hand, some new drilling was done in the Katalla oil field. Some oil properties were leased and preparations were made to render the field productive.

BUILDING MATERIAL, ETC.

Work continued on the only developed gypsum deposit in Alaska, located on the east side of Chichagof Island, in the Sitka district. The large marble quarry located at Shakun, at the north end of Prince of Wales Island, continued shipments throughout the year. Some small shipments of garnets were made from the Wrangell district, in southeastern Alaska, in 1910. An investigation was made of the sulphur deposits of Makushin Volcano, on Unalaska Island, at the east end of the Aleutian chain, to determine the feasibility of mining them.

GEOLOGIC FEATURES OF ALASKAN METALLIFEROUS LODES.

By Alfred H. Brooks.

INTRODUCTION.

Thirteen years of systematic investigation of the mineral resources of Alaska by the Geological Survey has yielded a large amount of information relating to the geology of the mineral deposits. This has been used for the most part only in the descriptions and discussions of the economic geology of the individual districts about which reports have been published. Heretofore relatively little attention has been paid to the relation of the mineral deposits of different parts of the Territory to one another or to other broader problems of economic geology. Practically the only exception is the geology of the coal fields, which has been briefly summarized.[1] Therefore anyone desiring information about the areal distribution and geologic occurrence of the metalliferous deposits must seek it in nearly two score publications.[2]

It is proposed to summarize briefly in this paper the salient geologic features of the metalliferous deposits of Alaska, using the results obtained by the many geologists who have worked in this field. As the facts and their interpretation are taken largely from published reports, it will be evident that this article can lay no claim to being an original contribution to the geology of the ore deposits. It is hoped that the matter presented will be useful, not only to those who are developing the metallic wealth of the Territory, but also to those who may desire a convenient outline of the more purely scientific results which have been achieved.

Alaska is rich in metallic wealth. Its lode and placer mines up to the close of 1910 have produced[3] about 8,411,467 fine ounces of gold, valued at $178,789,171; 2,130,199 fine ounces of silver, valued at $1,286,678; 33,795,108 pounds of copper, valued at $5,338,709; and about $100,000 worth of tin. The rapid advance of the mining

[1] Brooks, A. H., The coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pp. 515-571. Martin, G. C., The Alaska coal fields: Bull. U. S. Geol. Survey No. 314, 1907, pp. 40-46. Brooks, A. H., Alaska coal and its utilization: Bull. U. S. Geol. Survey No. 442, 1910, pp. 47-100.

[2] See list of publications at end of this volume.

[3] Statistics of mineral production are presented in detail on pp. 24-28.

industry, which had its beginning in 1880, is indicated by the fact that over 80 per cent of the gold, almost 75 per cent of the silver, and all of the copper and tin have been produced during the last decade.

The lode production, which is the more important to the subject of this paper, includes all the copper, 2,346,635 fine ounces of gold, valued at $48,662,775, and 1,001,241 fine ounces of silver, valued at $611,608. Of this amount, the copper, 1,544,916 fine ounces of gold (value $31,845,549), and 452,190 fine ounces of silver (value $262,630) have been produced in the last 10 years. Most of the tin is from placers, but there has been a small output from lodes.

The above statistics of the output of precious metals serve only to indicate the advancement in productive mining. Of more importance to the future of the industry is the large amount of work accomplished during the last few years in prospecting and developing lode deposits. This is true not only of long-established lode-mining camps on the Pacific seaboard but also of many inland districts. These developments are constantly adding new facts bearing on the occurrence of metalliferous lodes, and hence a paper like the present one can be regarded only in the nature of a progress report, which should be succeeded by others after more exhaustive studies of the several districts have been made.

GEOGRAPHIC AND GEOLOGIC DISTRIBUTION OF METALLIFEROUS LODES.

INTRODUCTION.

The distribution of the metalliferous lodes in Alaska is indicated on the accompanying map (Pl. I, in pocket), on which the localities of metal deposits are indicated by symbols. It would undoubtedly add much value to this paper if the distribution of the metals could have been shown on a geologic map, but such a map was not practical in this report, intended for early publication, because of the time needed both to compile the geologic data and to publish a map in colors. The larger features of the areal geology of some of the more important parts of the Territory are represented on Plates II, III, and IV, which will be supplemented by brief verbal descriptions of the geology of the entire province.

The general map (Pl. I) strikingly illustrates the very wide distribution of gold in the Territory. It will be shown that the gold is so widespread because the conditions for its deposition in the bedrock existed over large areas during Mesozoic time, rather than because there are many types of auriferous deposits or because they were formed during many epochs of geologic history. Copper, too, occurs in several widely separated districts, but there is less uniformity in the form of its occurrence than in that of the gold deposits.

The copper deposits are probably also chiefly of Mesozoic age. The tin deposits are practically all limited to one district and to one general epoch of formation.

The marked parallelism of the larger bedrock structures which prevails throughout much of Alaska has had a wide influence on the areal distribution of many of the stratigraphic subdivisions, and hence on the mineral deposits associated with them. These structures parallel the Pacific seaboard of Alaska, trending northwestward to about the one hundred and forty-ninth meridian, thence swinging to the west and southwest. As the position of the dominant mountain ranges and systems has been determined by these structures, their axes have the same trends.

The structures above noted have determined to a large extent the areal distribution of the bedrock formations, especially of those older than Upper Cretaceous. As a result of these tectonic lines, many of the geologic subdivisions occur in belts which parallel the Pacific seaboard. As it is impossible to present here a complete summary of the geology of Alaska, its larger features can probably best be elucidated by describing briefly the successive zones of rocks, similar in general lithology or age, which form the larger stratigraphic units, together with the metal deposits associated with them. These formations or zones will be described, so far as possible, in their geographic sequence from south to north. The order of treatment will have to be modified to a certain extent and some of the local geology will be presented by provinces, defined by drainage basins.

PACIFIC COAST REGION.

Four large stratigraphic units have been recognized in southeastern Alaska (see Pl. II). (1) A series of Paleozoic sediments locally interbedded with greenstones, including terranes varying in age from Silurian to Carboniferous and in places highly metamorphosed. The recent investigations of Knopf in the Juneau district show that locally, at least, Mesozoic sediments are closely infolded with some of these Paleozoic rocks and that some of these are highly metamorphosed. (2) A series of Mesozoic sediments (Lower Cretaceous or Jurassic) made up largely of clastic material. (3) The great batholiths of the Coast Range, comprising intrusive rocks varying in composition from granite to diorite and later than Middle Jurassic in age. Intrusive rocks of this age and composition are also widely distributed in isolated stocks or dikes. (4) Some small areas of Tertiary (Eocene) sediments and lavas.[1] In general, all these rock groups can be said to occur in a series of belts which are parallel to the northwest-southeast trend of the coast line. On the east the province is bounded by a broad belt of granitic intrusive rocks,

[1] There are also some recent lavas, which will not here be considered.

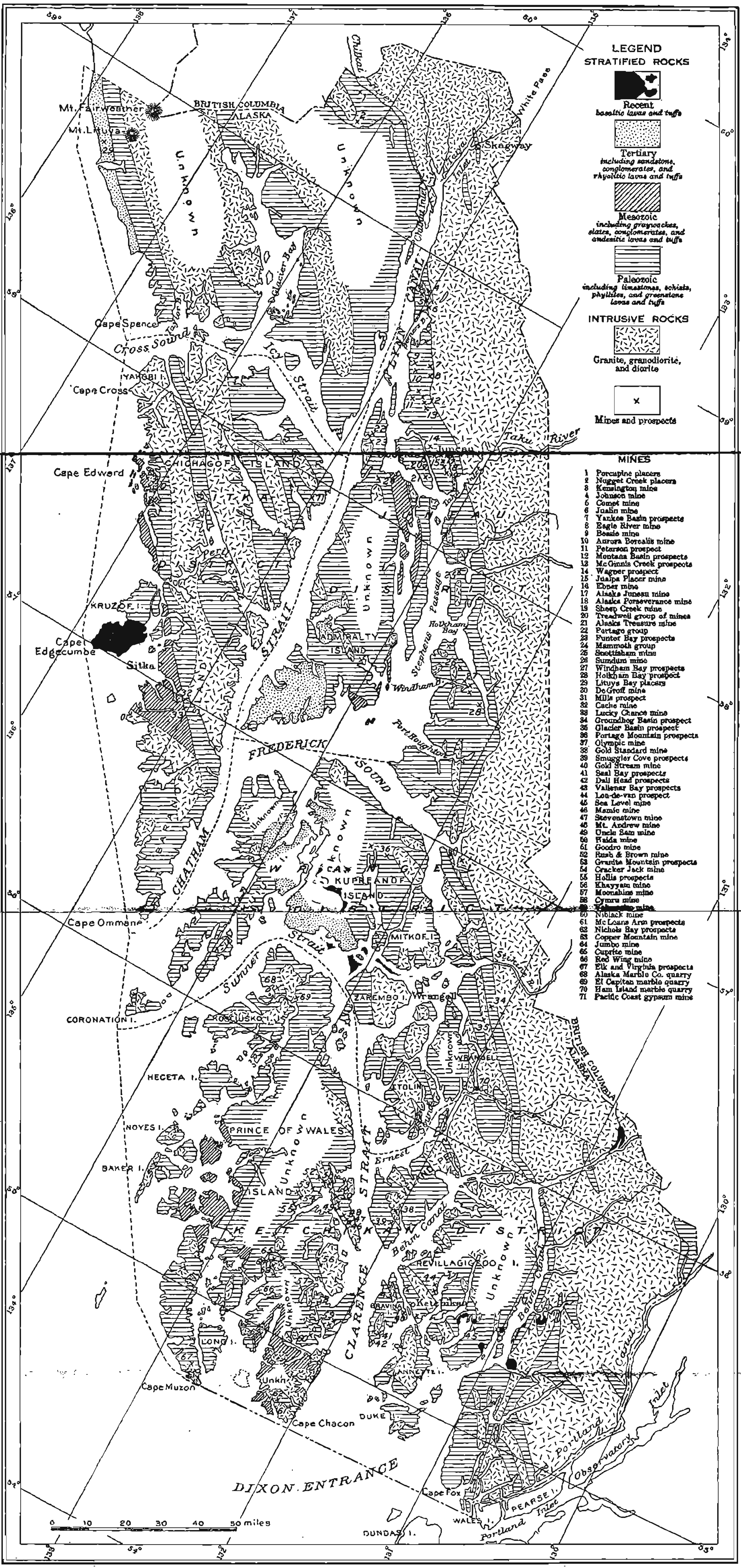
forming the Coast Range. Adjacent to these intrusive rocks on the west is a series of deformed Paleozoic and Mesozoic sediments. In most places a belt of metamorphosed sediments lies immediately adjacent to the granites of the Coast Range. A less altered series of Mesozoic or Paleozoic rocks lies next to the west. These have been locally metamorphosed by intrusive rocks lithologically similar to those of the Coast Range. The Mesozoic rocks occur in several broken belts within the areas of Paleozoic formations. One of the largest known of these belts skirts the westernmost islands of the Alexander Archipelago in the vicinity of Sitka.

The best-developed and largest known auriferous ore bodies of the Territory occur in a belt of Mesozoic and Paleozoic sediments (see Pl. II) skirting the mainland of southeastern Alaska and usually separated from the granitic batholiths of the Coast Range by a zone of crystalline schists a mile or more in width. Within this general zone of mineralization is included the Juneau gold belt, from which most of the lode gold of Alaska has been produced. This is a well-defined belt of mineralization from Snettisham on the south to Berners Bay on the north; but some gold has been found in both the northern and southern extensions of this belt.

In addition to the deposits occurring in this zone, auriferous quartz veins have also been found in or near the marginal zones of some of the outlying intrusive masses occurring in different parts of the Alexander Archipelago. Noteworthy examples of these auriferous lodes are those found in the slates and graywackes, probably of Mesozoic age, of the Sitka region. These rocks do not seem to have been metamorphosed by granitic intrusions, which are, however, not far distant. In southeastern Alaska auriferous deposits are also found within the intrusive masses themselves.

The Ketchikan district contains some important copper deposits. Of these, the best-known type is that which occurs in the contact zones of Paleozoic limestones and intrusive rocks, but there are also other types.

An extension of the strike lines of the formations of southeastern Alaska will carry them into the unexplored heart of the St. Elias Range. At Yakutat Bay two groups of rocks have been recognized. The eastern group, which probably forms the bedrock of the high ranges, is made up of crystalline and semicrystalline altered sediments, probably chiefly Paleozoic, with many intrusive rocks. The western, called the Yakutat group, consists of very highly contorted sediments, with some greenstones and other rocks, which have been provisionally referred to the Mesozoic. Little is known of the metalliferous resources of this district; but the fact that the glacial gravels derived from the St. Elias Range are locally more or less auriferous makes it probable that some gold-bearing quartz veins occur in the mountains.



GEOLOGIC RECONNAISSANCE MAP OF SOUTHEASTERN ALASKA.

Showing relation of ore deposits to intrusive rocks. By F. E. and C. W. Wright, 1907.

On tracing the coast line westward, metamorphic rocks of unknown age are found at Controller Bay, but are not known to carry any metalliferous deposits. These rocks are unconformably overlain by a closely folded sequence of Tertiary age bearing bituminous and anthracite coal.

Still farther west, on Prince William Sound, there is an older (probably Paleozoic) series of more or less altered sediments (Valdez group) overlain by a series of sediments and ancient lavas (Orca group), which are probably of Mesozoic age. Both series are closely folded and are locally cut by granitic intrusive rocks. The Chugach Mountains, which form the coastal barrier north of Controller Bay and Prince William Sound, so far as known, are made up of closely folded sediments, probably belonging to the same two groups of formations, and these are locally auriferous. In the western part of Prince William Sound the bedrock formations swing to the southwest, and the same groups of metamorphic sediments occur in the eastern part of Kenai Peninsula. These are succeeded near Kachemak Bay, on the southwestern part of the peninsula, by Mesozoic beds. Most of the western half of Kenai Peninsula is covered by little-disturbed Tertiary lignitic coal-bearing rocks and by Quaternary gravels. The geology of Kodiak Island is little known, but it is probable that metamorphic sediments of the same age as those of Kenai Peninsula form the dominating country rock, with small scattered areas of Tertiary lignite-bearing sediments.

On Prince William Sound cupriferous deposits have been found in association with the greenstones and sediments of the Orca group. Deposits of similar types occur near Resurrection Bay, an indentation of the northeastern part of Kenai Peninsula, and are reported from Kodiak Island. Auriferous quartz veins have been found at a number of places on Prince William Sound, occurring in slates and graywackes of both the Orca and Valdez groups. Similar types of occurrence are found in Kenai Peninsula in what is probably the extension of the same groups of sediments. Some gold deposits have also been found on Kodiak Island. None of these deposits are known to have such marked association with intrusive rocks as has been noted in the metalliferous veins of southeastern Alaska.

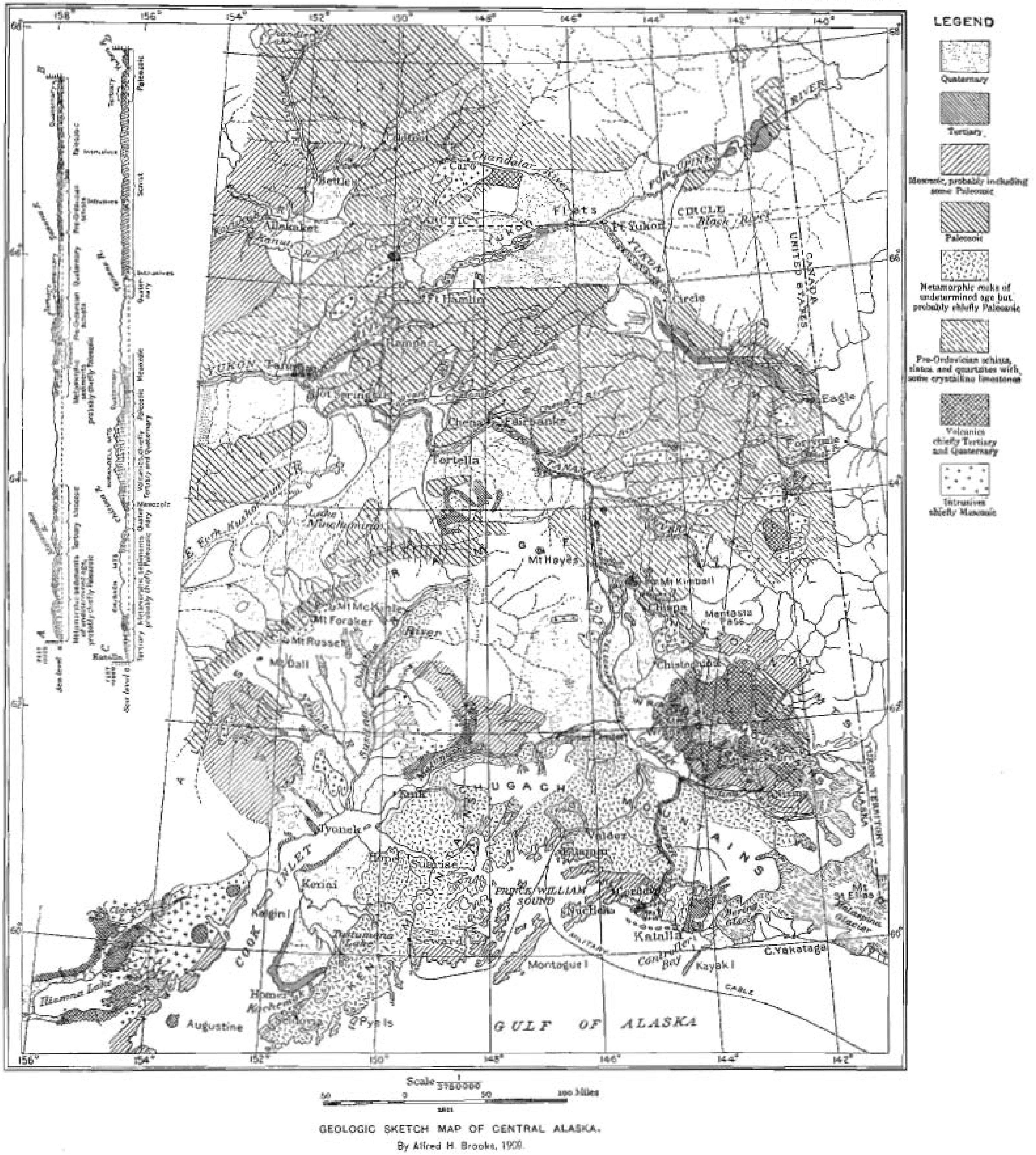
That part of the Iliamna region which lies adjacent to Cook Inlet is occupied chiefly by sediments and volcanic rocks of Mesozoic age, which are thrown into broad open folds. On the west the Mesozoic is bounded by a broad belt of granitic rocks locally altered to gneisses and probably intruded chiefly in Jurassic time. Within the granite area are some small belts of metamorphic greenstones, limestones, slates, and cherts, which may be Paleozoic but whose age is undetermined. Volcanic rocks and sediments, chiefly of Mesozoic age, lie adjacent to the granite on the west. These form the country rock of much of the shores of Iliamna and Clark lakes. In this field there are also some very extensive Tertiary and recent volcanic rocks. In the Iliamna region there are some auriferous and cupriferous ore bodies which occur chiefly in the altered sediments of Paleozoic or younger age at and near the contact of intrusive rocks. Some placer gold has been found in the Mulchatna basin, lying west of Lake Clark, but its geologic association is not known.

Mezozoic and Tertiary sediments and volcanic rocks, so far as known, form the country rock of much the larger part of the Alaska Peninsula and adjacent islands. The typical structures seem to be open folds with considerable faulting. Granitic intrusive rocks have not been found in that part of the Alaska Peninsula which has been examined, and there is but little evidence of metallization. The Aleutian Islands are unsurveyed and geologically almost unknown. It seems probable, however, that they are largely built up of volcanic rocks, of which a part are certainly recent, some may be of Tertiary age, and some are as old as the Mesozoic. Some intrusive granite stocks occur in this province.

The developed metalliferous deposits of southwestern Alaska are confined to Unga and Popof islands, where auriferous veins occur in lavas, probably of Mesozoic age. Some auriferous mineralization is, however, known at other localities, notably on Unalaska Island, where it is found in volcanic rocks (probably Mesozoic) near the contact with an intrusive stock of granite.

COPPER RIVER REGION.

The Chugach Mountains, which bound the Copper River basin on the south, are made up of closely folded sediments, more or less altered and intruded by igneous rocks, and carry some auriferous deposits. The broad alluvium-filled Chitina Valley, between the Chugach Mountains on the south and the Wrangell Mountains on the north, separates two provinces whose geology is quite different. (See Pl. III.) The Wrangell Mountains are probably formed by a broad syncline or synclinorium. Along the south arm of this syncline the sequence consists of a series of ancient volcanic rocks (Carboniferous or Triassic), called the Nikolai greenstone, succeeded conformably by the Chitistone limestone (Triassic), and this in turn by several formations of Mesozoic sediments capped by a great complex of volcanic rocks, which are in part recent and in part may be Tertiary. The north arm of the syncline, as exposed in the upper basins of White, Chitina, and Nabesna rivers, shows Carboniferous limestones and greenstones, succeeded by Mesozoic beds, and these in turn by the recent volcanic rocks. Mesozoic intrusive rocks are fairly abundant in these formations. The direct correlation of the older beds on the two arms of the syncline has not been possible with the



GEOLOGIC SKETCH MAP OF CENTRAL ALASKA.

By Alfred H. Brooks, 1909.

information at hand. On the west the Wrangell Mountains fall off to the broad gravel-filled basin which stretches from the Copper to the Susitna basin.

The best-developed ore deposits of this region are the copper-bearing lodes occurring along the southern flank of the Wrangell Mountains and chiefly in the basins of Kotsina and Chitina rivers, which are tributary to the lower Copper. These deposits occur in the Nikolai greenstone and Chitistone limestone, principally near the contact of the two formations. (See Pl. VI.) Copper occurs also on the northern flank of the Wrangell Mountains, in the basins of White River and of tributaries of the Tanana, where the associated sediments are, however, probably chiefly Paleozoic, and some of these deposits are along contact zones of intrusive diorite. The gold of the Nizina placers, in the upper Chitina basin, has been derived from quartz veins occurring in Upper Jurassic sediments near contacts with quartz diorite intrusive rocks.

North of the Wrangell Mountains lies a belt of closely folded Mesozoic sediments which constitute the Nutzotin Mountains. To the west these mountains merge with the Alaska Range, but there appears to be a marked change in their component strata. In the basin of the Chistochina the foothills of the Alaska Range are made up of upper Paleozoic sediments and volcanic rocks, with later intrusives. This series is separated by a great fault from a belt of metamorphic schists which constitute the greater part of the mountains to the north. On tracing these mountains westward, the geology is again found to change. In the upper Susitna basin the southern mountain front is made up of Mesozoic slates and greenstones of undetermined age which have been invaded by large masses of granitic rocks. In the heart of the range, however, the metamorphic schists are believed to dominate.

The gold of the Chistochina placers, in the northern part of the Copper River basin, appears to have been derived from quartz veins in Carboniferous sediments in a contact zone of intrusive granodiorites. No lode deposits have been developed in this field, but in the Nabesna basin, 60 miles to the east, some work has been done on a lode which appears to be a mineralized zone between a granodiorite and contact-metamorphosed limestone. The Valdez Creek placers have derived their gold from slates which are probably of Mesozoic age. These slates, like those of the Juneau gold belt, are separated from the granitic intrusive rocks by a zone of highly metamorphosed sediments.

SUSITNA AND MATANUSKA BASINS.

The region lying north of Cook Inlet falls into two general geologic provinces, separated by the Susitna Valley. (See Pl. III.) On the east are the Talkeetna Mountains, made up largely of granitic intrusive rocks believed to be chiefly of Mesozoic age, with a marginal zone of metamorphic sediments. Along the southern flanks of these mountains, drained by Matanuska River, Eocene coal-bearing beds and Jurassic and Cretaceous sediments and volcanic rocks, with possibly some Paleozoic sediments, have been found. These formations, where they lie against the granite, are intensely deformed and faulted. Toward the central part of the Matanuska Valley, however, the Tertiary beds and associated Mesozoic sediments are less disturbed but are cut by many intrusive rocks. Some Tertiary (post-Eocene) volcanic rocks are also found in this province. The metamorphic sediments of the Chugach Mountains, already described, form the southern boundary of the Matanuska Valley.

The geology of the region north of the Talkeetna Mountains is but little known. The bedrock appears to be in part metamorphic sediments, in part little-altered Mesozoic sediments and volcanic rocks.

Some auriferous deposits have been found along the margins of the Talkeetna intrusive rocks. Those developed include the gold placers and lodes of the Willow Creek district. (See pp. 139–152.) Copper deposits are also reported in this province.

The Alaska Range, which bounds the Cook Inlet depression on the west and north, is made up of Paleozoic and Mesozoic sediments thrown up into a broad synclinorium, along the west limb of which there has been profound thrust faulting. These sediments are cut by many large stocks of granite and some of more basic rocks. Though the granitic rocks are of the same type and age as those of the Talkeetna Mountains, they differ in appearing to have brought about but little contact metamorphism. A series of closely folded slates, provisionally assigned to the Paleozoic, occurs along the eastern foot of the Alaska Range. These are believed to form the bedrock of the Yentna placer district, and the occurrence near by of large intrusive masses of granitic rocks suggests a genesis of the auriferous deposits similar to that described for other parts of the Territory. The slates are succeeded by a great complex of Jurassic volcanic rocks, with some sediments (Skwentna group), which are locally auriferous, though they have not yet yielded any commercial deposits. Jurassic slates and graywackes (Tordrillo formation) rest on the volcanic rocks unconformably. Some auriferous mineralization is reported to occur along the contact zones of these slates and the granitic intrusive. The Jurassic sediments have also been recognized along the west arm of the syncline, but here the volcanic rocks (Skwentna group) are absent and the Jurassic sediments rest unconformably on Paleozoic sediments made up of Ordovician, Devonian, and possibly Silurian (Tatina and Tonzona groups) and Carboniferous (?) (Cantwell formation). Some little-disturbed Tertiary coal beds occur along the eastern margin of the range. Tertiary beds are also involved in the profound dislocations along the western base of the range. The Mesozoic beds which form the central part of the synclinorium in the southwestern part of the range do not extend through to the Broad Pass region, where there appear to be only Paleozoic rocks. To the east along the range the recognizable Paleozoic sediments appear also to die out, for the main range in the Valdez Creek region, as already stated, seems to be made up largely of metamorphic schists (Birch Creek?) and granites. The western extension of this schist passes north of the main range in the Nenana basin and here appears to be auriferous, for it forms the bedrock of the Kantishna placer district.

YUKON AND KUSKOKWIM BASINS.

A series of highly metamorphosed sediments of great thickness, called the Birch Creek schist, forms the oldest rocks of the Yukon basin and is probably of pre-Ordovician age. This series is typically made up of quartz-mica schists and mica schists. A common phase is a micaceous quartzite. It also includes crystalline limestones and some greenstone schists which are altered igneous rocks. Gneissoid granites are extensively developed here and there in the schist areas.

The Birch Creek schist is typically developed in the Yukon-Tanana region, where it occupies a broad belt striking westward from the international boundary through to Fairbanks, on Tanana River, forming the country rock of the important placer fields of this province. (See Pl. IV.) North of the Yukon a second belt of schists, of a similar type and probably of the same age, extends westward from the Chandalar placer and lode district into the Koyukuk placer district. Another belt of schists about which little is known but which are probably of the same age occurs in the Kaiyuh Mountains. These mountains lie between the lower Yukon and Innoko districts, which are known to be auriferous, though no commerical placers have been found in this region as yet. This belt probably crosses the Yukon above the mouth of Melozitna River and stretches through the unsurveyed area lying between the Yukon and the Koyukuk. In Fairbanks and Chandalar, as well as in other districts, auriferous quartz veins have been found in the Birch Creek schist. The auriferous mineralization, both in the lode and placer districts, seems to be closely related to granitic intrusive rocks. The age of these granites is probably Mesozoic and is known to be in part Upper Cretaceous.

In the Yukon-Tanana region the Birch Creek schist is succeeded unconformably by many thousands of feet of Paleozoic sediments ranging in age from Ordovician to late Carboniferous. It is beyond the scope of this paper to describe in detail the formations which go to make up this great sequence. Before Upper Devonian time there was a period of diastrophism which deformed the beds previously deposited, and these older formations are known to be locally mineralized and to form the source of some of the placer gold. These older beds are also developed in other parts of the Yukon region and adjacent portions of the Kuskokwim basin.

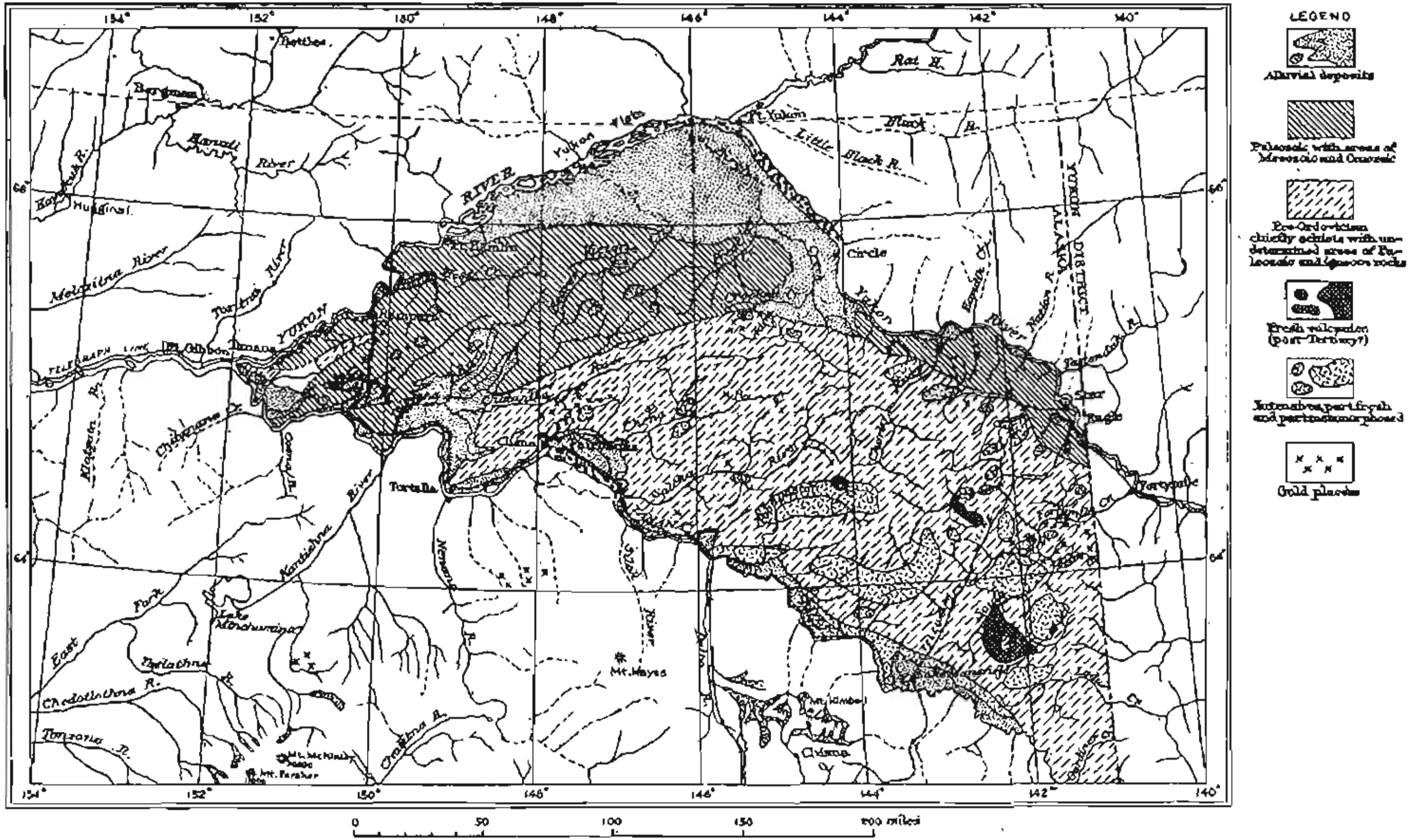
The Mesozoic is represented in the Yukon region by some Triassic limestone and in the Yukon and Kuskokwim basins by widely distributed clastic rocks with some volcanic rocks of Lower Cretaceous or Jurassic age. These rocks are especially well developed in the lower Yukon, Koyukuk, and Kuskokwim valleys and in the Norton Bay region. In the Yukon-Tanana region these Jurassic or Cretaceous rocks do not seem to be loci of important ore deposits, though they are known to be locally mineralized. On the other hand, the gold of the placers of the Innoko-Iditarod region seems to have been derived from contact zones of these Mesozoic sediments and intrusive granites. (See pp. 243–246.) The same is probably true of the Bonanza Creek placers, on Norton Bay.

The only other hard-rock formations of this province are the Eocene and Upper Cretaceous strata, carrying lignitic and subbituminous coal. These beds appear to be widely distributed but do not occur in any large areas. As a rule they do not seem to be metallized, but in the Rampart region some Upper Cretaceous beds have been found which are cut by granite, and near the contact there are some small pyritized quartz veins.

SEWARD PENINSULA.

The Mesozoic sediments stretch westward from the lower Yukon until they lap over on the Paleozoic and older rocks of Seward Peninsula. These Paleozoic rocks constitute a series of varied composition, ranging in age from Cambrian to Carboniferous. They appear to rest on an older series, made up of schists and crystalline limestone and called the Kigluaik group, which may be of pre-Paleozoic age. Granitic stocks have been found in this older group, as well as cutting limestones as young as Carboniferous. There are also some schists, which are altered igneous rocks, infolded with the sediments of different ages. In the northeastern part of the peninsula Mesozoic or Tertiary volcanic rocks are extensively developed. A few small areas of Mesozoic or Tertiary lignitic coal-bearing rocks also occur on Seward Peninsula, as well as Quaternary lava flows.

The placer gold of Seward Peninsula appears to have been derived largely from contact zones of Paleozoic limestones and schists. There are also known occurrences of auriferous mineralization in slates and quartzites. In neither case can the mineralization be directly traced to the influence of intrusive rocks. The peninsula contains, however, some tin deposits, which are directly associated with granite stocks intruded in the Paleozoic sediments.



GEOLOGIC SKETCH MAP OF YUKON-TANANA REGION.

By L. M. Prindle, 1907.

NORTHERN ALASKA.

The geology of northern Alaska is but imperfectly known. On the Kobuk have been found metamorphic sediments, probably representing the same horizons as those of Seward Peninsula, which are, locally at least, auriferous. (See pp. 271–319.) There are also large areas of folded Mesozoic sediments that probably represent the same horizons as those of the lower Yukon.

Near Cape Lisburne occur Carboniferous limestones carrying high-grade coal, some clastic rocks provisionally referred to the Devonian, and a great thickness of folded Jurassic beds, which carry extensive deposits of subbituminous coal. Tertiary beds are also known to occur in this province.

In the section exposed along the Colville and its tributaries Schrader found a central area occupied by rocks of varied lithology and unknown age. South of these are the metamorphic schists of the Koyukuk basin, already described, and to the north are some closely folded and faulted Carboniferous limestones (Lisburne formation) and a heavy conglomerate and slate series of unknown age. North of the mountains these Paleozoic rocks pass underneath gently folded Mesozoic sediments, and these, in turn, under Eocene sediments. Throughout this section there is a striking absence of intrusive and volcanic rocks, and no metal deposits have been found. It is reported by prospectors that crystalline schists occur to the east, near the international boundary, and that some placer gold has been found there.

OUTLINE OF GEOLOGIC HISTORY.

INTRODUCTION.

What is known of the areal distribution of the larger stratigraphic units and their associated metals has been briefly presented in the foregoing pages. In this section will be given an outline of some of the more important events of geologic history which have produced these deposits. Many of these events will be very briefly touched upon, as they have only an indirect bearing on the subject considered, but special emphasis will be laid on those occurrences of the geologic past which are believed to have contributed directly to the formation of ore bodies. It will be impracticable to attempt to correlate all the events of the geologic history of different parts of the Territory; therefore the history will to a certain extent be recounted by districts, taken in order from south to north.

PRE-PALEOZOIC AND PALEOZOIC TIME.

Pacific seaboard.—A number of stratigraphic units, made up chiefly of limestones, cherts, and slates and ranging in age from Silurian to

Carboniferous, have been recognized in the Paleozoic rocks of southeastern Alaska. These represent periods of deposition which were probably interrupted by folding and erosion but need not here be considered in detail. In late Carboniferous or early Triassic time there were in this province extensive extravasations of the basic eruptive rocks, which are now found interbedded with sediments. The metallization all seems to have taken place in post-Paleozoic time.

The broad belt of more or less metamorphosed sediments which skirts the Pacific seaboard from St. Elias westward to Kenai Peninsula (Valdez group) is probably of Paleozoic age or includes some Paleozoic rocks, but the Paleozoic history of this belt is obscure and need not be considered here, as the metal deposits of these rocks are probably of post-Paleozoic age.

Copper-Susitna region.—Records of Paleozoic sedimentation in the Copper-Susitna region are exceedingly meager, for only rocks of Carboniferous age have been definitely recognized. These are chiefly limestones or volcanic rocks, and there is no evidence that they were deformed, intruded, or metallized in pre-Mesozoic time. On the inland slope of the Alaska Range many thousands of feet of Paleozoic rocks were deposited. These have been divided into four groups, ranging in age from Ordovician to Carboniferous. Sedimentation was interrupted by several epochs of folding, followed by erosion. None of these rocks show evidence of mineralization in Paleozoic time, and their earlier geologic history is therefore not pertinent to this discussion.

Yukon and Kuskokwim basins.—Little is known of the sequence of events by which the Birch Creek schist—the oldest formation of the Yukon basin—was formed, but it consists certainly for the most part of sediments deposited in early Paleozoic or pre-Paleozoic time. After the deposition and induration of these sediments they were invaded by igneous rocks of various types and still later, but probably in pre-Ordovician time, they were intensely deformed while under a heavy rock cover. Before this deformation and possibly accompanying or immediately after the igneous intrusions, quartz veins were injected, some of which appear to have been metalliferous. These veins were folded and broken by the subsequent deformation and now occur chiefly as stringers, thin lenses, and vugs, which constitute the oldest system of veining in the region and do not seem to be of economic importance. Uplift and a long period of erosion of this complex seem to have taken place before the deposition of the oldest known Paleozoic formation of this field, which has been assigned to the Ordovician. The important auriferous mineralization of the Birch Creek schist, as will be shown below, is believed to have taken place in Mesozoic time.

The sequence of geologic events in the Yukon region during Paleozoic time up to the Middle Devonian is far from being established. It is known that there were long periods of deposition interrupted by epochs of erosion, and the resulting strata have been divided into several rock groups, including some which are known to be Ordovician, some Silurian, and some probably Lower Devonian. There appears to have been no notable metallization of these rocks during these periods of diastrophism. The Middle Devonian is characterized by a siliceous limestone which is very widely distributed in Alaska and which in the Yukon-Tanana region is associated with a great thickness of volcanic rocks, chiefly of a basic character, which at a later time were locally mineralized.

It is probable that after the deposition of the Middle Devonian beds there were extensive crustal disturbances, and these may have been accompanied by some quartz veining. The later Paleozoic history of the Yukon is of no significance to the problems here under discussion, and it will suffice to state that in Upper Devonian and Carboniferous time there were two periods of erosion, but that there appears to have been no interruption to sedimentation from Paleozoic to early Mesozoic time.

Seward Peninsula.—A Cambrian limestone is the lowest formation in Seward Peninsula whose age has been determined, but some schists and limestones have been found that may be older. In general, the known Paleozoic of the peninsula is represented by vast thicknesses of limestones ranging in age from Upper Cambrian to Carboniferous. Intercalated with some of these are schists which are in part known to be of igneous origin and various clastic rocks. The whole sequence has been so intensely deformed as to defy subdivision except after most detailed investigation.

An injection of quartz veins took place previous to this deformation, and these are now found as small irregular lenses and stringers. Many of these veins are metallized and some are said to be gold bearing. It is an open question whether the placer gold was derived to any extent from the older system of veining, or whether its source is largely in the younger unsheared veins referred to below. This latter epoch of auriferous mineralization is provisionally assigned to the Mesozoic, as is also the mineralization which produced the deposits of cassiterite, galena, etc., which are all more or less intimately associated with granites that are probably of post-Carboniferous age.

Northern Alaska.—Paleozoic rocks, in part of Carboniferous age, occur in the Endicott Mountains of northern Alaska, but the sequence of geologic events in this region has not been definitely determined. A series of schists, probably of Birch Creek age, occurs along the northern base of the Endicott Mountains, and probably has had the same geologic history. Similar rocks occur in the Kobuk Valley. The fact that there appears to have been no intrusion of igneous rocks or of metallized quartz veins in the Paleozoic areas of the Endicott Mountains is for the present discussion the most noteworthy fact in the geologic history of this region.

MESOZOIC TIME.

Economic importance.—From the standpoint of one interested in ore deposits, the Mesozoic was the most important era in the geologic history of Alaska, for nearly all the metallization which has formed commercial deposits and to which age assignment can be made falls within it. The time of most intense and widespread metallization can probably be still further limited to the Jurassic or Cretaceous and was thus synchronous with the mineralization which produced the valuable deposits of California and other parts of the western Cordillera. Therefore most of Alaska's metallic deposits belong to the same metallogenetic province as those of the western United States. It is not to be understood by this that the ore deposits are in any sense confined to Mesozoic horizons, for this is far from being the case. In fact, except in southeastern Alaska and in a few other districts the metalliferous deposits occur chiefly in pre-Mesozoic rocks. The mineralization which caused ore deposits took place, however, in Mesozoic time.

Stratigraphic sequence.—Sedimentary and volcanic rocks of Triassic age are widely distributed in Alaska. In general the Triassic appears to have been a period of limestone deposition, with possibly some local volcanic outbursts. So far as known, there are only a few localities where ore deposits occur with Triassic rocks. The most noteworthy of these are in the Copper River region, where copper deposits occur in the Chitistone limestone, of Triassic age, and in an older series of ancient lava flows (Nikolai greenstone), of either Triassic or Paleozoic age.

The Orca group, of Prince William Sound, is perhaps Triassic, but it is not possible now to speak with precision in regard to its age. It can be subdivided into a lower member, in which ancient volcanic rocks dominate, with some clastic rocks, and an upper member, in which slates and graywackes dominate, with some volcanic rocks. The lithology of these rocks is very different from that of the Triassic rocks of other parts of Alaska, where calcareous deposits are the rule and the clastic and volcanic rocks are the exception. Sedimentation was closed at about the end of Triassic time by a widespread crustal movement, followed by erosion.

During Jurassic time deposition of fragmental material took place over much of Alaska. Many thousands of feet of sandstones and argillites, with some volcanic rocks, were laid down, and sedimentation was probably interrupted by periods of erosion. The Jurassic history is complex and need not be considered for the purposes of this report. One phase of it which deserves mention, however, is the volcanic outburst in the southwestern part of the Alaska Range and in the Alaska Peninsula. The rocks of this epoch are locally auriferous, though they have not yet been the source of any large amount of gold. In late Jurassic and early Cretaceous time extensive deposits of argillaceous and arenaceous sediments were accumulated over much of Alaska, and these were subsequently folded and more or less altered. These Jurassic and Cretaceous sediments are important loci of gold deposits in southeastern Alaska and elsewhere. They appear to form the youngest beds which have yielded any commercial ore bodies, though some evidence of mineralization has been found in rocks as young as the Upper Cretaceous.

Intrusive rocks.—The genesis of most of the Alaskan ore bodies is more or less directly traceable to the influence of intrusions which took place during Mesozoic time. During this period of intrusion probably most of Alaska south of the Endicott Mountains was injected by igneous rocks. The intrusions began in early Jurassic time, possibly in some parts of the region in Triassic or even in late Paleozoic time, and culminated during Lower Cretaceous time, but continued in some places into the Upper Cretaceous. This epoch of volcanism followed and accompanied crustal movements which were continental in their effect and as a result of which many of the main structural lines were established. Along these lines, however, some movements took place later.

The great batholiths of the Coast Range of southeastern Alaska were probably intruded during Jurassic and Cretaceous time. The northwesterly extension of this same belt of intrusive rocks carries them into the Alaska Range, where large stocks of igneous rocks are common. All these intrusive rocks show the same lithologic facies, ranging from granites to diorites in composition. Rocks of the same varieties and of approximately the same age of intrusion are found in the batholiths of the Talkeetna Mountains, north of Cook Inlet. Granitic rocks are abundantly developed in the Iliamna region, some of which, however, may be of Paleozoic age. Mesozoic granitic intrusive rocks are also found in the lower Yukon and Kuskokwim basins and in the Norton Bay region. The age of the granites of Seward Peninsula is unknown, but they are, in part at least, later than rocks known to be of Mississippian age and are probably Mesozoic. It is impossible to speak with precision as to the age of the granitic rocks of the upper Yukon basin. At one locality they cut Upper Cretaceous rocks, and the presumption is fair that they are in greater part of Mesozoic age and to be correlated with those of the other parts of Alaska whose age has been more definitely fixed.

In addition to the granular intrusive rocks, dikes of similar chemical composition but differing mineralogically occur in many parts of Alaska and seem to belong to the same period of intrusion. This period of intrusion was probably long continued in some parts of the province, where there were probably several series of intrusions, the later ones being injected after the first had been solidified and fractured. Thus, in southeastern Alaska the main granitic masses were fractured and injected by acidic aplitic dikes, which represent the last phase of this epoch of volcanism. Similarly, the metalliferous quartz veins were introduced after the igneous intrusives—in fact, after these were solidified and fractured. The genesis of the quartz veins is therefore probably related closely to that of the granite.

The wide distribution of the metalliferous deposits in the contact zones of the igneous and country rock has already been pointed out. The gold and copper deposits of southeastern Alaska and of the Iliamna region, the gold deposits of the Nizina, Yukon-Tanana, Chistochina, Yentna, Willow Creek, Koyukuk-Chandalar, Innoko-Iditarod, and possibly those of Prince William Sound and Kenai Peninsula, all appear to be genetically related to the Mesozoic intrusive rocks. In fact, the auriferous deposits of Seward Peninsula are the only ones for which there does not seem to be some rather clear evidence that their mineralization is genetically related to igneous rocks, and in most of the auriferous districts there is good reason to believe that the intrusions took place in Mesozoic time.

TERTIARY AND QUATERNARY TIME.

The geologic history of Tertiary and later time bears only indirectly on the occurrence of metalliferous lodes. The Eocene was essentially an epoch of lacustrine and fluviatile conditions, when extensive deposits of coal accumulated. This was followed by a period of diastrophism, in which most of the folding of the rock strata now visible took place and was accompanied by some basic intrusion and extravasation of volcanic rocks. So far as known, there was no mineralization during this period of deformation. It is, however, important in the consideration of the distribution of the metals, because it determined in many districts the attitude and areal distribution of the beds with which the metals are associated.

Late Tertiary and Quaternary history is replete with geologic interest but has little bearing on the present discussion. Its later phases had to do with the accumulation of the alluvium in which the gold placers occur. In the Quaternary, too, occurred an epoch of glaciation which removed from the mountains of the coastal system, and to a less extent from those of northern Alaska, the débris resulting from the previous weathering, and in some places deeply channeled the drainage courses. This phase of the geologic history has one important bearing on the lode mining, inasmuch as the glacial ice, in part at least, removed the upper zone of rock material in which the secondarily enriched mineral deposits should be found. It is probably safe to conclude that in most places where glacial scouring was active no deposits which have been secondarily enriched by surface waters occur;[1] in any event, no such deposits have yet been recognized in Alaska except at very shallow depths.

THE ORE DEPOSITS.

INTRODUCTION.

For the purpose of systematic description the lode deposits will be thrown into several large groups, each of which will be made to include all the deposits chiefly valuable for a certain metal. Within each group further subdivisions will be made, based primarily on geologic association and only secondarily on considerations of mineralogy and genesis. This rough classification will, it is believed, serve the present purposes and will accord with the limitations placed on this discussion, both as to length and as to precision of data used. It will, at least, have the merit of making no pretense at anything except immediate utility and will leave a clear field for the formulating of a genetic scheme of classification by those who have made a more exhausitve study of the subject than the writer has.

GOLD.

OUTLINE.

The gold-bearing lodes which are more or less closely associated with intrusive rocks form by far the most important group of auriferous deposits in Alaska, and these intrusives are, as has been shown, chiefly if not wholly of Mesozoic age. A second group of gold deposits which for the present will be regarded as distinct, comprises those of Seward Peninsula, for these are not known to have a genetic relation to intrusive rocks. Each of these larger groups can be further subdivided in accordance with the country rock in which they occur and the character of the openings in which they were deposited. Thus, those associated with igneous rocks will be subdivided according as they occur in the intruded or in the intrusive rock. Each of these subdivisions can be further separated into fissure veins, impregnated zones, and stockwork deposits. It will be evident from what follows that there are some mixed types of deposits which it will be difficult to fit into this scheme of classification.

DEPOSITS ASSOCIATED WITH INTRUSIVE ROCKS.

GENERAL STATEMENT.

The auriferous deposits of southeastern Alaska, as already pointed out, furnish the best examples of the close association between Mesozoic intrusive rocks and ore bodies. This fact is well illustrated

[1] It will be evident that other factors, such as temperature of water, and hence climate, presence or absence of vegetation, also enter into the problems connected with secondary enrichment, but these will not be considered here.

by the geologic map of this province (Pl. II, p. 46), on which the localities of auriferous ore bodies are indicated. These ore bodies, while they bear a close relation to the intrusive rocks, do not occur in the zone of igneous metamorphism but in the adjacent sediments, which are less highly altered. This seems to be true of all the deposits. In those lodes which lie close to or at the contact of intrusive rocks there is as a rule no great amount of igneous metamorphism.

LODE DEPOSITS IN THE INTRUDED ROCKS.

The best-developed auriferous deposits are those of the Juneau gold belt, which, according to Spencer,[1] occur in a well-defined lode system that skirts the mainland both north and south of Juneau. The country rock is chiefly argillite, with some igneous rocks, which can be collectively classed as greenstones of late Paleozoic or Mesozoic age and lie close to, though not in contact with, the Coast Range batholith.

The dominant ores are those carrying free gold and iron pyrite, but pyrrhotite, chalcopyrite, galena, sphalerite, arsenopyrite, stibnite,

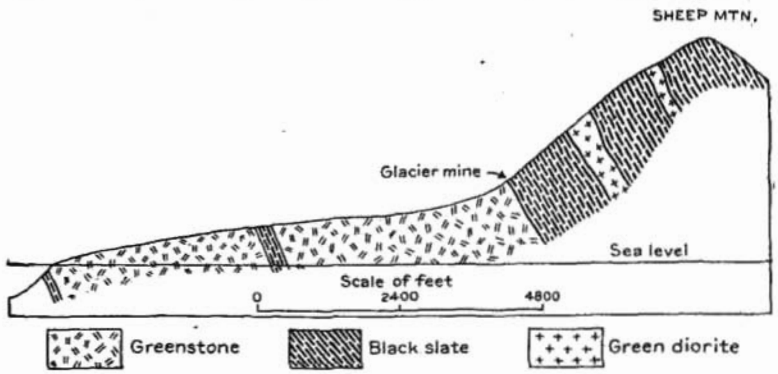


FIGURE 1.—Profile section from mouth of Sheep Creek to Sheep Mountain, Juneau district, showing locus of auriferous mineralization. By A. C. Spencer, 1903.

tetrahedrite, molybdenite, pyrargyrite, and magnetite have also been found. Quartz is the chief gangue mineral, but calcite and other minerals also occur.

Spencer recognizes two types of ore bodies—(1) the veins, which include the mineral aggregates deposited in fractures of the country rock, and (2) the impregnated zones, in which the metallic minerals are disseminated, more or less irregularly, through masses of the country rock. Some deposits, as that of the Treadwell (see pp. 67–69), appear to combine both types of ore bodies. These general types have also been recognized in other parts of Alaska.

A good example of the vein deposits is that on Sheep Creek, near Juneau. Here the country rock is a part of the slate-greenstone

[1] Spencer, A. C., The Juneau gold belt, Alaska: Bull. U. S. Geol. Survey No. 287, 1906, pp. 21-137.

series typical of the Juneau belt, which is cut by diorite dikes. The ore bodies occur at a slate-greenstone contact near the intrusive diorite. In figure 1 the locus of mineralization is indicated by the position of the Glacier mine. At this locality three parallel veins occur in the slates, near the greenstone contact (fig. 2), and these veins, with a number of others lying farther from the greenstone contact, occupy a mineralized zone some 400 feet wide. The fissures are in general parallel to the cleavage, but in places they cut across it.

Across the divide from Sheep Creek, to the northwest, in the valley of Gold Creek, the same general geologic conditions for the occurrence of the ore bodies prevail. The deposits all occur in the greenstone-slate series near contacts with the intrusive rocks. Here the principal mineralization has produced stringer leads which are complex networks of quartz veins following two systems of fractures and constituting a deposit of the impregnated-zone type. Many of these lodes occur directly at the contact of diorite and slate, the diorite being more or less altered.

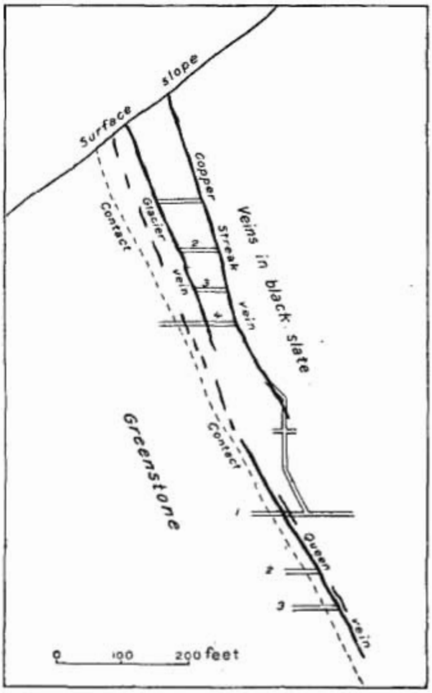


FIGURE 2.—Generalized cross section of Silver Queen and Glacier mines, Juneau district, illustrating the relation of the zone of mineralization to the slate-greenstone contact. By A. C. Spencer, 1903.

In addition to the deposits of the mainland belt some mineralization has been found in the greenstones of the western part of Douglas Island. Here the country rock consists of slates and greenstones and the ore bodies consist of impregnated zones of fracture. Spencer[1] notes that pyrite is the chief metallic mineral in these deposits, but galena, sphalerite, and chalcopyrite have also been found. Albite and rutile occur as gangue minerals.

Auriferous deposits have also been found in the argillite and greenstones which skirt the mainland and adjacent islands west of the granites of the Coast Range in the Ketchikan district, south of Juneau. Here some small fissure veins have been found, but deposits of the disseminated type appear to dominate and have yielded but

[1] Spencer, A. C., The Juneau gold belt: Bull. U. S. Geol. Survey No. 287, 1906, pp. 92-93.

few commercial ore bodies. These deposits occur in rocks which lie adjacent to areas affected by contact metamorphism due to granite intrusion. They include some auriferous quartz veins, but the prevailing type of deposit is the mineralized fracture zone. These zones occur especially in the greenstone schists and are characterized by an abundance of iron pyrite with but little gangue. Their gold values are usually low, but some of them carry lenses and vugs of quartz very rich in free gold.

Deposits of the fissure-vein type have also been found in many parts of the Ketchikan district[1] but so far have yielded no very large or very rich ore bodies. Most of these occur in or are intimately associated with porphyry dikes and will be considered later (pp. 69–70).

The auriferous quartz veins of the Sitka region, described by Mr. Knopf on page 98 of this volume, cut a graywacke series, which is probably of Mesozoic age. No intrusive rocks occur in the immediate vicinity of the ore bodies, but a large stock of granite is known to lie a few miles to the east. Auriferous veins have also been found at a number of places on Prince William Sound,[2] notably at Port Valdez and McKinley Lake. Here again the association with intrusive rocks is not definitely established. On Port Valdez the bedrock consists of a closely folded sequence of slate and graywackes belonging to the Valdez group. The veins appear to follow a well-defined system of fissuring. At the Cliff mine, which is the only deposit examined, the ore is blue quartz carrying much finely disseminated pyrite with minute quantities of arsenopyrite and high values in free gold. Some of the veins have been crushed and recemented by quartz.

The gold-bearing veins of Kenai Peninsula[3] appear to be similar in character. They are quartz veins carrying pyrite, arsenopyrite, and free gold. At one locality some telluride has been found.

Mr. Moffit's description of the Valdez Creek placers (pp. 119–127), in the upper Susitna region, and of the Chistochina placers, both of which occur in argillites, also indicates a close relation between the bedrock source of the gold and the granitic intrusive rocks. To this type of deposit should probably also be added the deposits of Bonanza Creek,[4] near the eastern shore of Norton Bay, where, however, no gold has yet been found in the bedrock.

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[1] Brooks, A. H., Preliminary report on the Ketchikan district, Alaska: Prof. Paper U. S. Geol. Survey No. 1, 1902. Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts: Bull. U. S. Geol. Survey No. 347, 1908.

[2] Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: Bull. U. S. Geol. Survey No. 443, 1910.

[3] Grant, U. S., and Higgins, D. F., Preliminary report on the mineral resources of the southern part of Kenai Peninsula: Bull. U. S. Geol. Survey No. 442, 1910, pp. 166–178.

[4] Smith, P. S., and Eakin, H. M., A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region: Bull. U. S. Geol. Survey No. 449, 1911.

In the Yukon-Tanana region as a whole, but more especially in the Fairbanks district, there appears to be a close genetic relation between the gold deposits and the granite intrusive rocks. (See Pl. IV, p. 52.) At Fairbanks, where some work has been done on lodes, two systems of quartz veining have been recognized, both of which cut the Birch Creek schist. In addition to these, quartz stringers occur in the laminations of the schists and have been involved in the folding. The crosscutting quartz veins of the older generation appear to be larger than those of the later system, but while they carry some iron pyrite, the gold values appear to be low. After their introduction these veins were brecciated [1] and the bedrock was again fractured. The openings thus formed were impregnated by mineral-bearing solutions. In this way the older system of veins was enriched and some new veins were formed. The metal contents of the deposits due to the second period of mineralization are free gold, pyrite, stibnite, arsenopyrite, galena, and sphalerite. Quartz is the chief gangue mineral, with some calcite and locally orthoclase, calcite, albite, and tourmaline. The general distribution of the quartz veins indicates that there is a mineralized zone which parallels the main structures of the country rock but which is not very well defined (fig. 3). There have been some recent lode developments in the Chandalar placer district, north of the Yukon, where the conditions are probably similar to those at Fairbanks and where the deposits occur in close relation to intrusive rocks.

In addition to the fissure veins the Fairbanks district contains lode deposits which are probably comparable to those of the Juneau district described as mineralized zones. These are zones of fracture in the schists which have been permeated by mineral-bearing solutions. They are characterized by networks of small metalliferous quartz veins, forming stringer-lead deposits. In some places the quartz veining is only a very subordinate phenomenon, the main mass of the deposit being made up of pyritized schist carrying some gold. Only a few assays have been made on this type of deposit, but these indicate that the gold values are low. A deposit of this kind in the Bonnifield district is described by Mr. Capps on page 230. Here the country rock appears to be an altered and highly schistose rhyolite and not a sediment, as is the case in the Fairbanks district. It also seems probable that the gold of the placers of Willow Creek, in the Susitna basin (see pp. 145–146), has been derived from similar mineralized zones in a crystalline schist. This occurrence appears to be of a somewhat different type from those previously described, for it seems to lie within the zone of igneous metamorphism.

[1] Prindle, L. M., Auriferous quartz veins of the Fairbanks district: Bull. U. S. Geol. Survey No. 379, 1910, pp. 210–229.

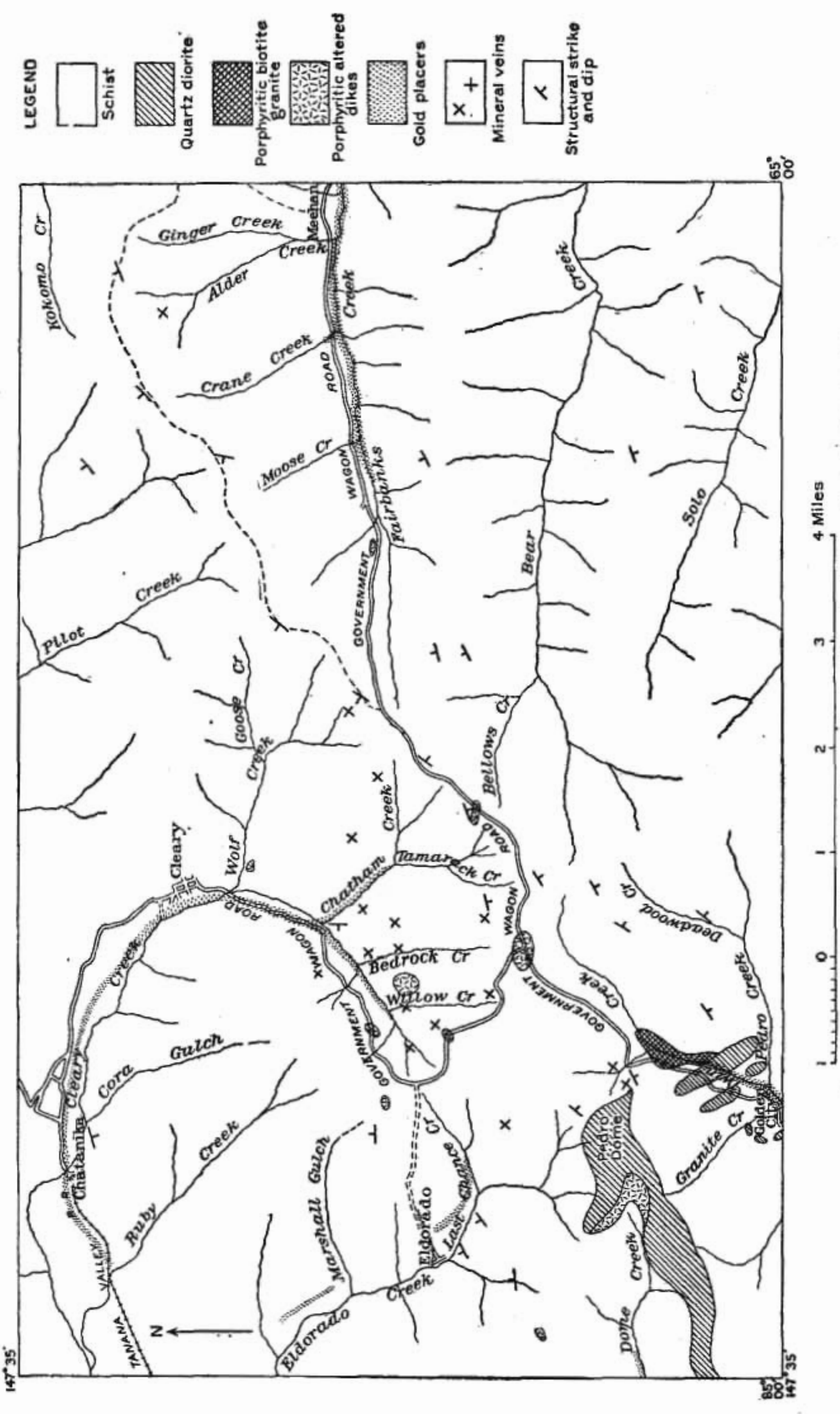

FIGURE 3.—Geologic sketch map of auriferous lodes in Fairbanks district. By L. M. Prindle, 1909.

As a general rule, the mineralized zones in the bedrock appear to occur in the schists, where the movements have not brought about notable open spacings but have formed crushed zones subsequently permeated by the mineral-bearing solutions. Such disseminated deposits seem to be more favorable to the formation of placers than where the ores occur in better-defined fissures. Where the physical character of the country rock has induced fractures with open spaces rather than shear zones, deposits of the fissure-vein type are more likely to be formed.

Auriferous veins that occur in crystalline limestones, usually near the contact with intrusive rocks, form another class of ore bodies which, however, differ from some of the silver-lead deposits to be described below only in the fact that they are valuable chiefly for their gold contents. This type of deposit is represented in southeastern Alaska by a number of ore bodies which have been more or less developed on Prince of Wales Island.[1] They occur typically in brecciated zones in crystalline and semicrystalline limestones, the openings thus formed having been penetrated by the mineral-bearing solutions and quartz and calcite, together with free gold, pyrite, chalcopyrite, tetrahedrite, galena, sphalerite, and arsenopyrite. These minerals have to a certain extent replaced the limestone, a fact which gives the ore bodies indefinite boundaries. Usually the values are distributed in shoots within the brecciated zone. Moffit and Knopf [2] have described the Royal Development Co.'s property at Jacksina Creek, in the Nabesna basin, as a mineralized contact zone between crystalline limestone and diorite. The entire mass has been sheared and heavily pyritized. At the surface at least it carries free gold, but it is not known what the form of the gold is below the zone of weathering.

Nearly all the gold deposits which have been described occur in rocks of sedimentary origin which have been subject to the influence of granitic intrusive rocks. In southwestern Alaska there is evidence of auriferous mineralization of volcanic rocks at and near the contact of granitic intrusives. Spurr [3] has described an example of this form of mineralization in a natural exposure on Skwentna River, north of Cook Inlet. The geologic relations are represented diagrammatically in figure 4. The mineralized area in the basalt along the granitic contacts in this and other localities contains pyrite, chalcopyrite, and galena, and assays show the presence of gold.

[1] Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska: Bull. U. S. Geol. Survey No. 347, 1908, pp. 81-82, 166-177. Brooks, A. H., Preliminary report on the Ketchikan mining district, Alaska: Prof. Paper U. S. Geol. Survey No. 1, 1902, pp. 54, 77-88.

[2] Moffit, F. H., and Knopf, Adolph, Mineral resources of the Nabesna-White River district, Alaska, Bull. U. S. Geol. Survey No. 417, 1910, p. 58.

[3] Spurr, J. E., A reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 111-112, 259.

Evidence of mineralization in volcanic rocks of the same age has been found in other parts of this region.[1]

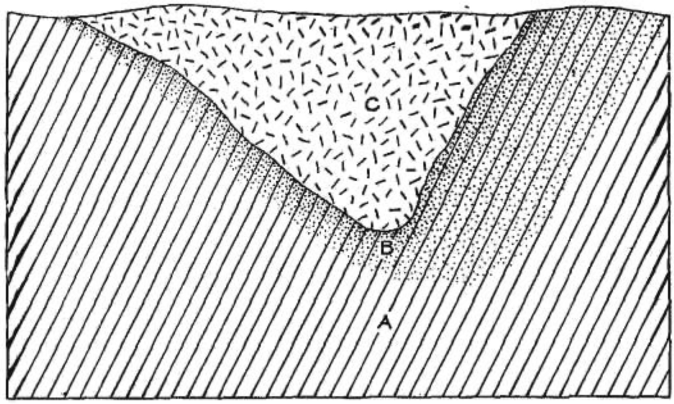

FIGURE 4.—Diagrammatic section of exposure in canyon of Skwentna River, illustrating mineralization in basalt along contact of granite dike. By J. E. Spurr, 1898. A, Ancient basalts; B, same, impregnated by metallic sulphides; C, intrusive granite.

The only developed lode in southwestern Alaska is the Apollo mine, on Unga Island. This deposit has been described by Becker [2] and others as occupying a zone of fracture in a country rock of dacite and andesite. Becker considered the volcanic rocks as of Miocene or post-Miocene age, but Atwood has called this determination in question and believes that they are certainly pre-Miocene and may be Mesozoic. Atwood also reports some dacite dikes on Unga Island, though none were observed in the immediate vicinity of the ore body. The metallic minerals of the deposit are free gold, pyrite, chalcopyrite, galena, zinc blende, and native copper. Other deposits of similar character have been noted in the neighborhood. There is no direct evidence of the influence of intrusives on this mineralization.

Some auriferous mineralization [3] has also been noted on Unalaska Island, at the east end of the Aleutian chain. Here the bedrock consists of andesitic volcanic rocks, whose age is unknown but is probably Mesozoic. A large granitic stock lies near this occurrence, and there is evidence that it has had some mineralizing influence.[4]

LODE DEPOSITS IN THE INTRUSIVE ROCKS.

The lode deposits in the intrusive rocks include those in shear zones in massive granite or diorite and also mineralized dikes. A

[1] Brooks, A. H., The Mount McKinley region, Alaska: Prof. Paper U. S. Geol. Survey No. 70, 1911, pp. 163–164.

[2] Becker, G. F., A reconnaissance of the gold fields of southern Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 12, 83–85. Martin, G. C., Gold deposits of the Shumagin Islands: Bull. U. S. Geol. Survey No. 259, 1905, pp. 100–101. Atwood, W. W., Mineral resources of southwestern Alaska: Bull. U. S. Geol. Survey No. 379, 1909, pp. 149–151.

[3] Collier, A. J., Auriferous quartz veins on Unalaska Island: Bull. U. S. Geol. Survey No. 259, 1905, pp. 102–103.

[4] Jaggar, T. A., Journal of the Technology expedition to the Aleutian Islands in 1907: Reprinted from Tech. Review, vol. 10, No. 1, pp. 17–19.

good example of the first type is found in the Kensington lode, in the Berners Bay region of southeastern Alaska. According to Knopf [1] the ore body consists of an irregular mass of crushed diorite, marking a zone of movement within massive diorite walls (fig. 5). This fracture zone has been gashed by a multitude of quartz stringers, forming a stockwork deposit. It carries pyrite and, in at least one place, a little galena. More or less alteration of the diorite walls of the lode was noted. The outcrop of the Kensington lode is about half a mile east of a slate-graywacke series of Jurassic or Cretaceous age into which the diorite is intrusive. According to Knopf there are also well-defined fissure veins within the diorite of the Berners Bay region.

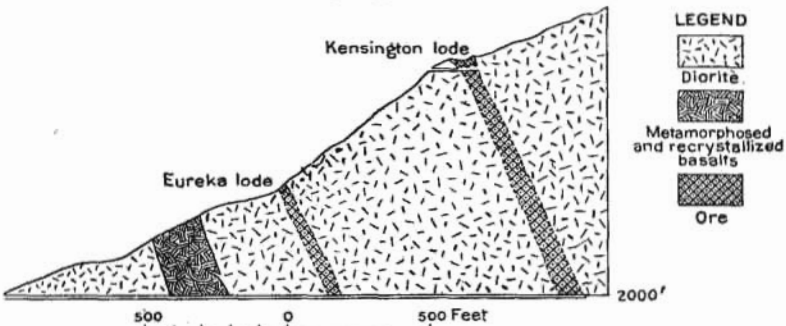

FIGURE 5.—Diagrammatic section along Kensington tunnel, Berners Bay, showing auriferous lode in diorite. By Adolph Knopf, 1909.

The ore deposits of the Treadwell group of mines also belong to this type of deposit, but the relations are not as simple as those at the Kensington. These mines, which are located on Douglas Island, near Juneau, and have produced over $40,000,000 worth of gold, form the largest mining enterprise in Alaska and one of the largest in the world, and their ore deposits will therefore be described in some detail. The following account is abstracted from Spencer's report: [2]

The ore bodies consist essentially of fractured and mineralized diorite dikes, which have penetrated a black slate parallel with and close to a greenstone contact (fig. 6). The greenstones appear to be altered volcanic rocks, and they, with the slates, constitute a part of the series which forms the country rock of much of the Juneau gold belt and is now regarded as probably of Jurassic or Cretaceous age. The fracturing of the diorite dikes has given opportunity for the mineralizing solutions to penetrate, and these have formed an intricate and irregular network of veinlets which can be designated as stringer leads. In addition to this, the ore-bearing solutions have permeated

[1] Knopf, Adolph, Geology of the Berners Bay region, Alaska: Bull. U. S. Geol. Survey No. 446, 1911, pp. 40–42.

[2] Spencer, A. C., The Juneau gold belt: Bull. U. S. Geol. Survey No. 287, 1906, pp. 88–116.

the diorite dikes, which have been largely altered to a mass of secondary minerals and vein matter. This mineralization has been traced by mine workings for almost 3,500 feet, with an extreme width of 400 feet. A depth of 1,600 feet has been attained without any notable change in values.

The dominating metallic minerals are free gold and pyrite, with considerable pyrrhotite and magnetite. In addition to these, chalcopyrite, galena, sphalerite, native arsenic, realgar, and orpiment have been found. Much of the gold is free, as high as 75 per cent of the assay value having been recovered. The important gangue minerals are feldspar, calcite, and quartz, with some rutile. Some of the original minerals of the diorite, such as feldspar, hornblende, and mica, are still present. Epidote, an alteration product of the primary minerals, is also found.

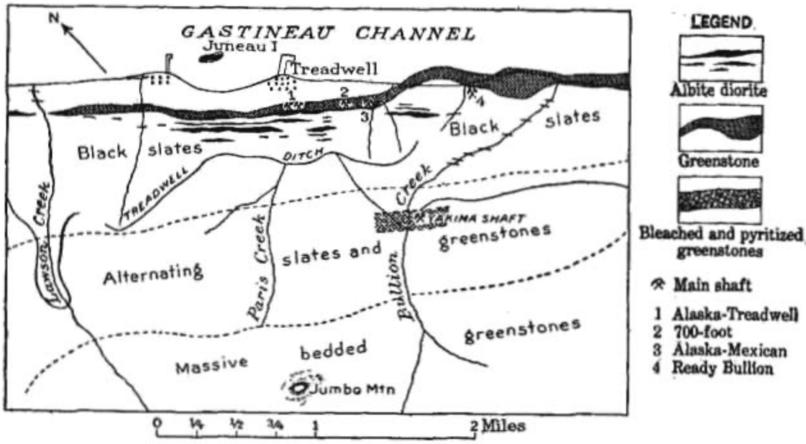

FIGURE 6.—Geologic sketch map of northwest end of Douglas Island. By A. C. Spencer, 1903.

The Treadwell ore bodies in their mode of origin and form of occurrence do not differ from some of the other deposits of the Juneau gold belt. Spencer has described the diorite adjacent to some of the lode deposits on Gold Creek as altered and more or less mineralized. It appears that in the Treadwell deposits the entire diorite mass was crushed, and the fractures thus formed gave opportunity for the mineral-bearing solutions to circulate, and the process continued until the whole dike was impregnated, while in deposits of the Kensington type the mineralization followed zones of crushing included within walls of massive igneous rocks.

Some auriferous veins have been found in a massive country rock of granite near Karta Lake, on Prince of Wales Island, in the Ketchikan district.[1] These veins follow fissures with well-defined walls and have a marked regularity in direction and thickness. In some places

[1] Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska: Bull. U. S. Geol. Survey No. 347, 1908, pp. 164-166.

diabase dikes have penetrated the fissures and have subsequently been fractured, and the auriferous quartz filling has been deposited along the spaces thus formed. The metallic vein minerals are free gold, pyrite, galena, and chalcopyrite, with a gangue of quartz, calcite, and possibly sericite.

The auriferous lodes of the Willow Creek region, north of Cook Inlet, described by Mr. Katz on pages 144–146, also belong to this type of deposit. These occur as fillings in what appear to be well-defined fissures in a quartz diorite country rock. Martin and Katz [1] have described a mineralized zone occurring within a granitic country rock near Cottonwood Bay, on Cook Inlet. This is described as a zone of shattering in a granite mass along which pyritiferous quartz veins have been deposited. Low gold values are reported. A mass of greenstone occurs near the ore body, and the granite is locally intruded by porphyry dikes.

At Orange Hill, in the Nabesna River basin, tributary to the Tanana, some auriferous mineralization has been found in a quartz diorite mass.[2] At this locality the diorite is cut by many small quartz stringers, some of them carrying pyrite and a few molybdenite. A similar deposit has been noted on Monte Cristo Creek, in the same region, and to the east on Beaver Creek, a tributary of upper White River. Several auriferous lodes have been found in the basin of Eureka Creek, also tributary to the White, which appear to be mineralized zones of fractures in a silicified feldspar porphyry.

The presence of auriferous deposits in granites and granodiorites is inferred from the distribution of placer gold in several districts. Thus the gold of the placers of Hill Creek, in the Fairbanks district, appears to have been derived from a mineralized zone in the margin of a granite stock. Mr. Maddren's description of the placers of the Iditarod (pp. 245–270) suggests that the gold was in part derived from a granite bedrock source. The writer [3] has also noted the occurrence of a mineralized zone in a granite 15 miles below Robertson River, on the north side of the Tanana Valley. Here both gold and pyrite were found disseminated in a brecciated zone about 10 feet wide, traversing a granite mass.

Mineralized dikes are not uncommon in many districts and some of these carry gold values. Such deposits have been found at the Sea Level mine and near Hollis, in the Ketchikan district.[4] Here the country rock is chiefly greenstone and calcareous schist (Mesozoic

[1] Martin, G. C., and Katz, F. J., Outline of geology and mineral resources of the Iliamna and Clark lakes region: Bull. U. S. Geol. Survey No. 442, 1910, p. 194.

[2] Moffit, F. H., and Knopf, Adolph, Mineral resources of the Nabesna-White River district: Bull. U. S. Geol. Survey No. 417, 1910, pp. 58–60.

[3] Brooks, A. H., Reconnaissance in the Tanana and White River basins, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 487.

[4] Brooks, A. H., Preliminary report on the Ketchikan mining district, Alaska: Prof. Paper U. S. Geol. Survey No. 1, 1902, pp. 66–67, 91–93. Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska: Bull. U. S. Geol. Survey No. 347, 1908, pp. 144–146, 160–161.

or late Paleozoic), which have been crosscut by porphyry dikes. These dikes have, in turn, been fractured and invaded by mineral-bearing solutions that deposited pyrite, galena, sphalerite, with some native gold, and quartz and a little muscovite as gangue minerals. The dike rock itself has in places been heavily mineralized.

At the Crackerjack mine, near Hollis, the country rock is slate, more or less graphitic, which has been invaded by a porphyry dike. The ore body lies adjacent to this dike, but the dike itself has been epidotized and pyritized. The ore carries pyrite, galena, sphalerite, and an undetermined black antimony or bismuth mineral, with quartz and a little calcite as gangue minerals. In both localities there are deposits of similar types which are not so intimately associated with the dikes.

A pyritized dike rock, which is associated with an auriferous lode deposit in the Moose Pass district of Kenai Peninsula, has been described by Grant and Higgins.[1] The dike is made up of a fine-grained aggregate of plagioclase, quartz, mica, and probably orthoclase, with scattered crystals of arsenopyrite. The mica is of a light-green color and is secondary after the feldspar. Maddren[2] has noted pyritized dikes which carry gold in association with quartz veins in the Innoko district. In this field intrusive granites are known to be close at hand.

LODES OF SEWARD PENINSULA.

The gold-bearing lodes of Seward Peninsula are here described separately because it can not be proved that they bear a genetic relation to intrusive rocks as do most of those already described. Smith,[3] to be sure, considers, that the intrusive granitic rocks of the Kigluaik Mountains were injected at the same time as some of the quartz veins of the Solomon-Casadepaga region. He also cites the presence of tourmaline in many of the rocks as evidence that granitic intrusives may underlie areas where they do not outcrop. The facts remain, however, that in those parts of the peninsula which, from the evidence of placer gold, must have been heavily mineralized no granitic intrusive rocks have been found and that no auriferous deposits have been found in the regions which are known to have been intruded by granite. Moreover, the type of mineralization in areas that have been invaded by granite has not produced ore bodies valuable for gold but deposits carrying tin, tungsten, galena, etc., and these (see pp. 87–90) appear to differ essentially from the veins and mineralized zones which have yielded the placer gold. It is therefore at least an open question whether this auriferous mineralization bears any direct genetic relation to the granitic intrusives.

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[1] Grant, U. S., and Higgins, D. F., Preliminary report on the mineral resources of the southern part of Kenai Peninsula: Bull. U. S. Geol. Survey No. 442, 1910, pp. 171-172.

[2] Maddren, A. G., The Innoko gold placer district: Bull. U. S. Geol. Survey No. 410, 1910, p. 64.

[3] Smith, P. S., Geology and mineral resources of the Solomon and Casadepaga quadrangles: Bull. U. S. Geol. Survey No. 433, 1910, pp. 132-133.

The writer [1] has shown elsewhere that the auriferous lode deposits of Seward Peninsula can be classed in two general groups—fissure veins and impregnated zones of fracture. There is also an older series of quartz veins, which lies parallel to the foliation of the schists and has been deformed with them, and these, too, locally carry sulphides and gold.

The distribution of the gold placers in the peninsula has helped to indicate the locus of auriferous mineralization in the bedrock where no other direct evidence was available. This class of evidence goes to show that, in the peninsula as a whole, the limestone-schist contacts were the most favorable places for auriferous mineralization.[2] An example of the relation of the mineralization to the limestone-schist contact is shown in the accompanying sketch map of the Ophir Creek region (fig. 7). The distribution of the placer gold at this locality indicates that it had its source in the limestone-schist contact. Moreover, at several places where this contact was studied in the field evidence of shattering and mineralization was observed. (See section A–B, fig. 7.)

Smith [3] has described the mineral veins of the Solomon-Casadepaga region in considerable detail, and those of the rest of Seward Peninsula are probably similar to these. He shows that there is an older system of quartz veining which may have been formed at a number of different periods of intrusion, all previous to the last epoch of intense deformation. The rock movement deformed the veins, which are now represented by blebs and bunches of quartz, irregularly distributed along the planes of foliation.

Besides being intensely folded and broken, the veins were crushed and then more or less recrystallized. The older veins are most abundant in the schists but occur also in the limestone, where they have usually not been much deformed. Metallic minerals are not common in these deposits, but some of them carry a little gold, some a little sulphide, and some rutile. Most of the younger series of quartz veins, as described by Smith, follow fissures which intersect the lamination of the country rock at different angles. These veins have as a rule suffered little deformation but are locally faulted. Some of them show comb structure and most of them have well-defined walls. These veins are again divisible into two types, one carrying locally visible free gold, with a gangue of quartz and but little sulphide, and the other carrying copper, iron, arsenic, and antimony sulphides, with no visible free gold.

Smith states that quartz veins occur in all the formations mapped, but they seem to be most abundant in the schists and slate. It

[1] Collier, A. J., Hess, F. L., Smith, P. S., and Brooks, A. H., The gold placers of parts of Seward Peninsula: Bull. U. S. Geol. Survey No. 328, 1908, pp. 110–139.

[2] Idem, pp. 121–124. Smith, P. S., Geology and mineral resources of the Solomon and Casadepaga quadrangles: Bull. U. S. Geol. Survey No. 433, 1910, pp. 141–142.

[3] Smith, P. S., Bull. U. S. Geol. Survey No. 433, 1910, pp. 89–93.

appears, from his work as well as that of others, that the limestone-schist contacts afforded conditions favorable to mineralization. The lithology of the country rock, however, except in so far as it affected

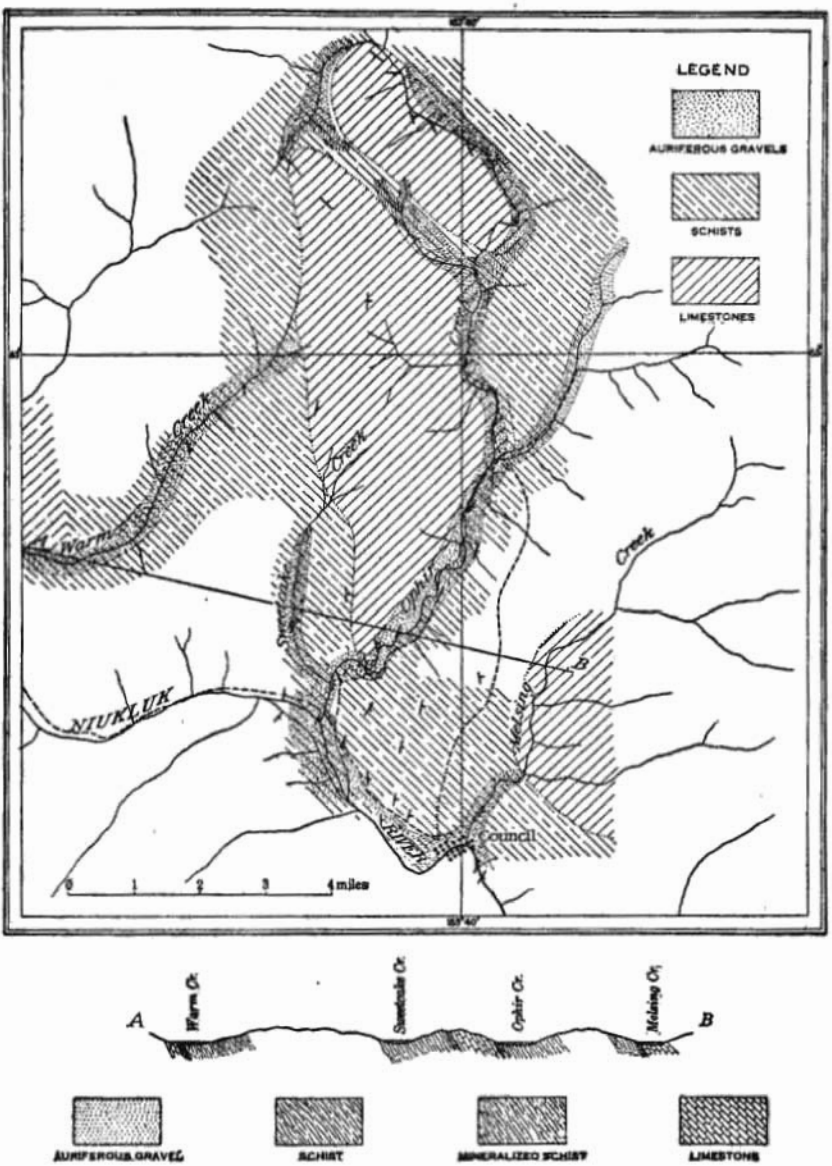


FIGURE 7.—Geologic sketch map and section of Ophir Creek region, Seward Peninsula, showing distribution of gold and of mineralization in relation to the limestone-schist contact.

the character of the fissuring, does not seem to have any influence on the formation of quartz veins. In the Solomon region the veins occurring in the Hurrah slate appear to be most persistent. This rock is well jointed and in places the deposits occur as a stockwork of veins, thus forming a transition to the impregnated zone and fracture type of deposit.

The Big Hurrah mine, in the Solomon basin, is the only auriferous-quartz deposit which has been developed to a productive basis. The country rock is a hard black graphitic quartzite[1] (Hurrah slate), which is much fractured and breaks into rectangular blocks. Numerous fractures occur throughout this formation and in many places it is seamed with quartz veins and stringers. These quartz veins, although they are believed to belong to the youngest system of veining, are more or less deformed. The gold of the Big Hurrah lode is almost entirely free and little or no sulphide is present. Much of the ore is banded with flakes and layers of graphite and graphitic schist. The vein has been opened to a depth of about 250 feet without any noteworthy changes in the character of the ore.

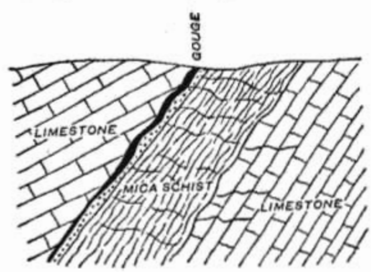


FIGURE 8.—Diagrammatic section of mineralized schist near Bluff, Seward Peninsula. By Alfred H. Brooks, 1905.

Smith also describes some calcite veins occurring in or close to limestone bedrock in the Solomon region. These veins, he states, carry no metallic minerals. It should be noted, however, that near Nome free gold has been found in calcite veins.

The more disseminated types of auriferous deposits of the peninsula, here called mineralized zones of fracture, are probably more common than fissure veins. In general they represent zones of fractured bedrock which have been permeated with mineral-bearing solutions. Some of these contain veins which may be stockwork or stringer-lead deposits. In others there is but little quartz and the deposit is defined by a zone of the bedrock which is heavily pyritized and in some places auriferous. Very few of these deposits are sufficiently well exposed to permit exhaustive study. It is not definitely known whether these deposits represent the older or the younger system of veining, but they probably belong to the younger. Mineralization of this type seems to be most pronounced at the limestone-schist contacts, where its distribution was determined by the fractures resulting from movements along the contact planes between the two formations.

Smith[2] has described the mineralized zones in the schist-limestone contacts of the Solomon and Casadepaga region as consisting of replacements of limestone by quartz with more or less sulphide minerals, of which chalcopyrite is most common. The writer's own

[1] Smith, P. S., Geology and mineral resources of the Solomon and Casadepaga quadrangles: Bull. U. S. Geol. Survey No. 433, 1910, pp. 144–145. Collier, A. J., and others, Gold placers of parts of Seward Peninsula: Bull. U. S. Geol. Survey No. 328, 1908, pp. 228–231.

[2] Smith, P. S., op. cit., pp. 141–142.

observations go to show that at some localities the zone of mineralization may be confined entirely to the schist but close to the limestone contact. An example of this is shown in figure 8, which is a diagrammatic section of a natural exposure near Bluff. Here a mass of schist, which is probably an altered igneous rock, is included between limestone walls. A series of gash veins cut across the foliation of the schist. These veins also penetrate the footwall of limestone. The metalliferous minerals noted in this deposit are pyrite, arsenopyrite, and chalcopyrite and are said to carry some gold.

COPPER.

OUTLINE OF CLASSIFICATION.

Practically all the Alaskan copper deposits thus far developed fall into five general groups determined by mode of origin or mode of occurrence. These are (1) deposits in zones of igneous metamorphism and chiefly near the contact of limestones with granodiorites and diorite intrusive rocks; (2) deposits associated with intrusive rocks, but not within the zone of igneous metamorphism; (3) deposits disseminated in intrusives; (4) deposits associated with ancient volcanic rocks and sediments; and (5) copper-bearing amygdaloids. Each of these groups admits of further subdivisions, which will be discussed later. This classification is summarized below.

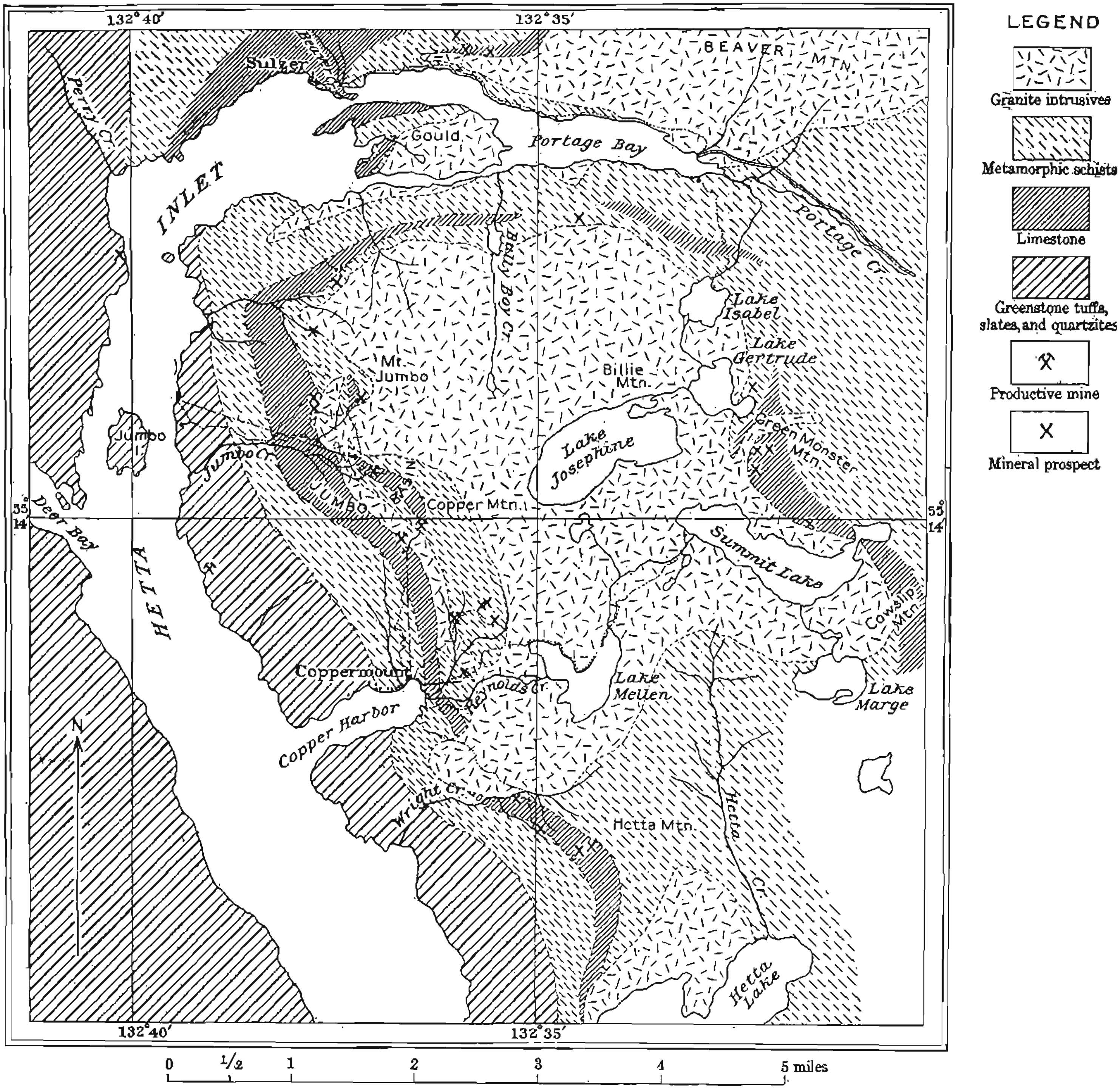
Classification of Alaska copper deposits.

1. Deposits in zones of igneous metamorphism.
    (*a*) Contact-metamorphic deposits of limestones and intrusive rocks.
    (*b*) Contact-metamorphic deposits of clastic and intrusive rocks.
2. Deposits associated with intrusive rocks, but not in zones of igneous metamorphism.
3. Deposits disseminated in intrusive rocks.
4. Deposits associated with ancient volcanic rocks and sediments.
    (*a*) Deposits occurring in greenstones and argillites.
    (*b*) Deposits occurring in greenstones and limestones.
5. Copper-bearing amygdaloids.

DEPOSITS IN ZONES OF IGNEOUS METAMORPHISM.

Copper-bearing lodes occurring in the contact zones of limestones and intrusive rocks are among the most widely distributed types of deposit in Alaska. The intrusive rocks are probably of Mesozoic age. Such ore bodies are especially abundant on parts of Prince of Wales Island, in the Ketchikan district of southeastern Alaska.[1] The geologic features of some of the best known of these deposits are shown on the accompanying map of the Copper Mountain region (Pl. V). Here an irregular stock of granite is surrounded by limestones and

[1] Wright, C. W., Mining in southeastern Alaska: Bull. U. S. Geol. Survey No. 379, 1910, pp. 80-82.



GEOLOGIC MAP OF COPPER MOUNTAIN REGION, SOUTHEASTERN ALASKA.

Showing relation of copper deposits to intrusive rocks. By C. W. Wright, 1908.

metamorphic schists and the copper deposits occur in the contact zone of limestone or schist adjacent to the granite. The ore bodies occur only where igneous metamorphism has taken place in the sediment adjacent to the granite, and this is by no means the case along the entire contact. Where this alteration has occurred a greenish or reddish rock has been formed composed chiefly of garnet and epidote and almost always carrying some disseminated chalcopyrite, pyrrhotite, and magnetite. This contact zone varies from 25 to 250 feet in width.

The ore bodies, which are of irregular outline and distribution, consist of chalcopyrite and pyrite in a gangue of garnet, epidote, calcite, and some quartz. They carry both gold and silver. Some of the deposits contain much magnetite; others lack this mineral but carry pyrrhotite. According to Wright the lodes were formed from solutions which penetrated along the contact, along preexisting fissures, or along solution channels in the limestone, or are replacement deposits of limestone where no notable opening previously existed. The important ore bodies usually lie along the contact, but from these smaller bodies of vein material branch out, penetrating both walls locally to a distance of a thousand feet.[1] The deposits in the schist near the contact are usually less concentrated than those in the limestone and are usually disseminated[2] along the planes of foliation. As a rule they do not form commercial ore bodies.

Many of the copper deposits of the east side of Prince of Wales Island, including those of Kasaan Peninsula, in the Karta Bay region, are also of the contact type. Wright's investigations[3] show that the sediments of this field include a series of conglomerates and graywackes and tuffaceous schists, which occur in broad areas, and narrow belts of limestones. The whole series has been folded and then extensively intruded by granular rocks which include granites, granodiorites, diorites, and syenites. These intrusives, which occur as irregular stocks and dikes, were followed by an injection of pegmatite dikes and, still later, by a widespread intrusion of porphyry dikes.

Contact deposits similar to those of Copper Mountain form the most widely distributed ore bodies of this region. They occur chiefly in the zone of igneous metamorphism at the contact of limestone and intrusive rocks. A few have been found at the contact of the graywacke-tuff series and the intrusives. The ores of the limestone contact are chalcopyrite, pyrite, pyrrhotite, and magnetite, with a gangue of epidote, garnet, amphibole, calcite, and orthoclase. These

[1] Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska: Bull. U. S. Geol. Survey No. 347, 1908, pp. 95-96.

[2] Brooks, A. H., and others, Mineral resources of Alaska—Report on progress of investigations in 1908: Bull. U. S. Geol. Survey No. 379, 1909, p. 81.

[3] Wright, C. W., Mining in southeastern Alaska: Bull. U. S. Geol. Survey No. 379, 1909, pp. 76-79.

deposits are typically irregular masses varying from 10 to 250 feet in width.

The shape of one of these ore bodies and its relation to the intrusive rocks is shown by the accompanying plan and section (fig. 9) of the workings of the Mount Andrew mine, on the southwest side of the Kasaan Peninsula. The ore bodies occur at the contact of a large intrusive mass and a belt of crystalline limestone.[1] In the plan and

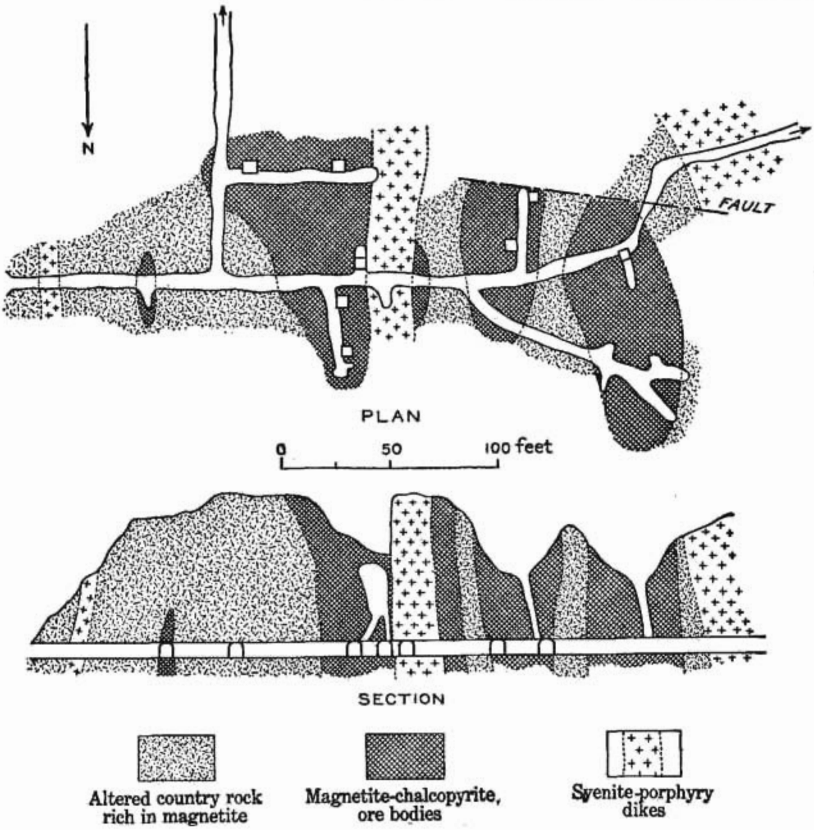


FIGURE 9.—Plan and cross section of Mount Andrew mine workings, Ketchikan district, showing position of ore bodies. By C. W. Wright, 1905.

section the altered country rock represents a metamorphic phase of the limestone and is made up of garnet, epidote, and calcite, together with a large amount of magnetite. This country rock has been cut by dikes of syenite, which are probably apophyses from the main mass of intrusive rocks that lies adjacent to the ore body on the east. The ore is composed essentially of chalcopyrite and magnetite and carries some gold and silver.

[1] Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts: Bull. U. S. Geol. Survey No. 347, 1908, pp. 115-117.

In this same region there are copper-bearing lodes which occur in the form of lenses in shear zones in the graywacke and tuffaceous

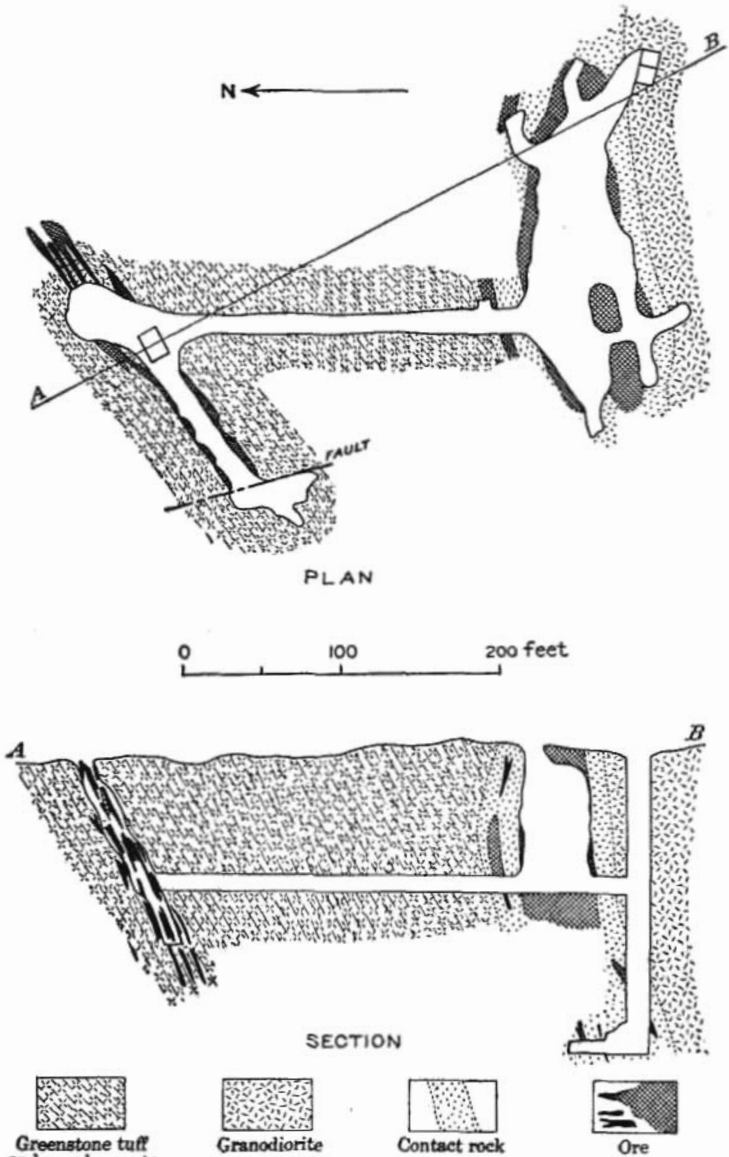


FIGURE 10.—Sketch plan and section of workings at Rush & Brown mine, near Karta Bay, showing ore bodies and relation of mineralization to contact between granodiorite and tuff and conglomerate. By C. W. Wright, 1905.

schist series but apparently in the zone of igneous metamorphism of intrusive masses. Their metallic minerals are chalcopyrite, pyrite, and usually sphalerite, with a quartz and calcite gangue. The Rush &

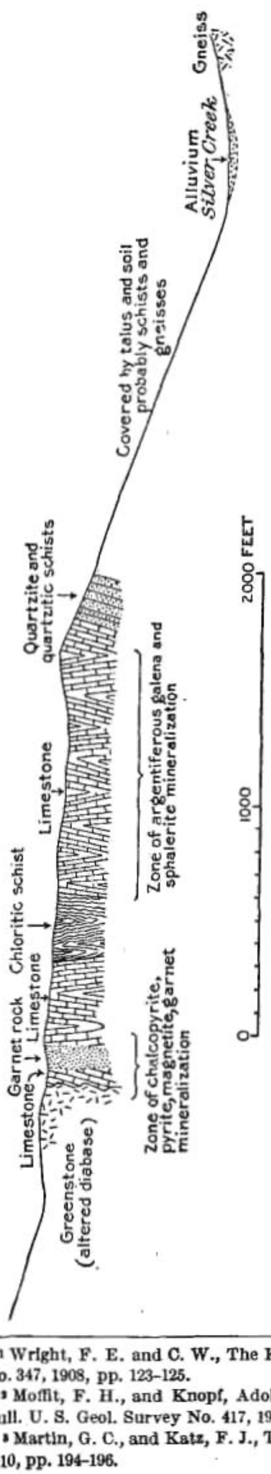


FIGURE 11.—Diagrammatic section near Cottonwood Bay, Iliamna region, showing mineralization at contact zone of limestone and diabase. By G. C. Martin and F. J. Katz, 1909.

Brown mine,[1] near Karta Bay, affords examples of both the contact-metamorphic ore bodies and those occurring in shear zones. Figure 10 indicates the geologic relations of the ore bodies at this locality. These deposits furnish the only example thus far developed in this district of igneous contact deposits in sediments other than limestones.

Moffit and Knopf[2] have described contact-metamorphic deposits of copper which occur in the basin of upper Nabesna River, tributary to the Tanana. These deposits are found in a crystalline limestone at or near the contact with dioritic intrusive rocks. The ores are bornite and chalcopyrite, associated with garnet, epidote, coarsely crystalline calcite, hematite, and scattered flakes of molybdenite. Some of these deposits also contain magnetite. The data at hand, which are fragmentary, as but little development work has been done, indicate that these deposits are similar in character to the contact deposits of southeastern Alaska.

The copper ores west of Cook Inlet, between Iliamna Bay and Iliamna Lake, occur in a contact zone[3] between limestone and a greenstone which is an altered diabase or diorite. The field relations are shown in figure 11. The mineralized zone, averaging 200 feet in width but in places reaching 300 feet, lies chiefly in the limestone but also in the greenstone. It contains chalcopyrite, pyrite, and magnetite, with a gangue of garnet, calcite, quartz, amphibole, and other minerals. The ore bodies consist of those parts of this mineralized zone which carry copper values with some gold.

[1] Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts: Bull. U. S. Geol. Survey No. 347, 1908, pp. 123–125.

[2] Moffit, F. H., and Knopf, Adolph, Mineral resources of the Nabesna-White River district, Alaska: Bull. U. S. Geol. Survey No. 417, 1910, pp. 52–55.

[3] Martin, G. C., and Katz, F. J., The Iliamna and Clark lakes region: Bull. U. S. Geol. Survey No. 442, 1910, pp. 194–196.

These Iliamna deposits, so far as the meager information about them permits comparison, bear a close analogy to the better-developed lodes of Prince of Wales Island. While the intrusive is of a more basic character and more highly altered, the contact zone and the ores are very similar. It should be noted that the mineralized zone and the two wall rocks lie within a great stock of intrusive granite, probably of Mesozoic age.

DEPOSITS ASSOCIATED WITH INTRUSIVE ROCKS BUT NOT IN THE ZONE OF IGNEOUS METAMORPHISM.

Some of the copper deposits of the Ketchikan district in southeastern Alaska lie within the zone affected by intrusive rocks but not within the areas of igneous metamorphism.[1] These deposits occur in association with greenstone schists, chloritic schists, and sericite schists, and with argillites and other sedimentary rocks. The greenstone and chloritic schists are probably chiefly altered igneous rocks. Some of them are known to be sheared intrusives. In most localities where the deposits occur intrusive rocks are known to be near at hand, and these are believed to be of Mesozoic age.

These copper-bearing lodes, so far as determined, occur along zones of fracture and usually have lenticular form. In some localities the ores appear to have been deposited in open spaces; in others the ore bodies consist of masses of country rock which have been impregnated by the mineral-bearing solution. No evidence has been seen of replacement of the country rock such as has been noted by Grant and Higgins in the deposits on Prince William Sound. (See p. 81.) The mineralized zone may include one or more ore shoots in the form of bands, veins, or lenses, and these are usually separated from both walls by the impregnated rock carrying lesser values. These deposits are valuable chiefly for their chalcopyrite. They also carry pyrite, pyrrhotite, in some places magnetite, and a little hematite and galena, with a gangue of quartz and calcite, as well as the minerals of the country rock. Among the localities where such deposits are found are Skowl Arm and Niblack Anchorage, both on the east side of Prince of Wales Island. The deposits at the south end of Gravina Island are probably of the same general type.

Ore bodies also occur in the greenstone schists and quartzites which overlie the limestones of Copper Mountain (see Pl. V), a mile or two from intrusive granite. These include both fissure-vein and shear-zone deposits. The ores contain pyrite and chalcopyrite, with a small amount of sphalerite.

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[1] Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska: Bull. U. S. Geol. Survey No. 347, 1908, pp. 128–140. Brooks, A. H., Preliminary report on the Ketchikan mining district: Prof. Paper U. S. Geol. Survey No. 1, 1902, pp. 74–96.

In this group should also be included copper-bearing fissure veins occurring in limestone of the Kasaan Peninsula region.[1] These veins carry chalcopyrite, galena, sphalerite, and tetrahedrite, with quartz, calcite, and barite as gangue minerals. In some places these deposits lie along the margins of intrusive dikes.

DEPOSITS DISSEMINATED IN INTRUSIVE ROCKS.

Copper ores occur as disseminated deposits in the intrusive rocks of the Kasaan Peninsula region.[1] The only commercial ore body of this type which has been developed is that of the Goodro mine, near the upper end of Kasaan Bay. This occurrence has been recently described by Knopf[2] as "a heavy green dioritic rock containing much biotite and, as the main copper-bearing mineral, scattered particles of bornite, with which are associated sporadic blebs of chalcocite and chalcopyrite." The ore body has been opened to a depth of 94 feet, where the copper content is said to be 2 per cent higher than at the surface. Knopf points out that this may be due to the greater prevalence of chalcocite on the lower level.

DEPOSITS ASSOCIATED WITH ANCIENT VOLCANIC ROCKS AND SEDIMENTS.

The fourth group of copper deposits comprises those which are associated with greenstones (altered volcanic rocks) and sediments of various types. These deposits, so far as known, have no direct relation to igneous intrusive rocks, but it is possible that in the deposits of the Prince William Sound type belonging to this group there may be a connection between the genesis of the ores and certain basic intrusive rocks. Of a different type, though belonging to this same general group, are deposits of the Chitina region which occur chiefly in limestones and are not connected with any intrusive rocks. While definite proof is lacking, it seems probable that the copper of both the Prince William Sound and the Chitina deposits was derived from copper minerals disseminated in the associated ancient volcanic rocks.

COPPER-BEARING LODES IN GREENSTONES AND ARGILLITES.

The best-known examples of the deposits in greenstones and argillites are those occurring in the Orca group of Prince William Sound and adjacent regions. The following description is abstracted from a report by Grant and Higgins.[3] The copper-bearing lodes occur along zones of fracture, in most of which shearing has taken

[1] Wright, C. W., Mining in southeastern Alaska: Bull. U. S. Geol. Survey No. 379, 1909, p. 78.
[2] Knopf, Adolph, Mining in southeastern Alaska: Bull. U. S. Geol. Survey No. 442, 1910, p. 141.
[3] Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: Bull. U. S. Geol. Survey No. 443, 1910, pp. 53-71.

place. These zones are mainly in greenstones that are altered basic lava flows and tuffs, with some intrusive rocks. Some of the mineralized shear zones occur in slates and graywackes and some along the contacts of the sediments and the greenstones. The shear zones strike parallel to the major structures of the region, with usually a steep dip. In some places the deformations have resulted in fracturing rather than shearing. So far as can be determined from the evidence in hand, the movements did not, as a rule, produce any notable open spaces, but there are exceptions to this, for at some localities fissure veins have been observed. Mineral deposition in the shear zones in part followed the open spaces thus formed and in part impregnated the country rock or replaced it where no notable open spacing occurred. Development has not proceeded far enough to admit of precise statement as to the shape of the ore bodies, but some of them at least appear to have a lenticular form, outlined by planes of movement. Some of the ore bodies have no well-defined walls. In many of the deposits there is an ore shoot, made up of more or less solid layers of metallic sulphide within the mineralized zone. These ore shoots vary more in dimensions from place to place than the deposits as a whole. Chalcopyrite is the most abundant of the metallic minerals and is usually associated with pyrrhotite. The proportion of these minerals varies greatly in a single ore body. Pyrite also occurs but is much less abundant. Among the rarer metallic minerals are galena, bornite, sphalerite, and magnetite. The chief gangue minerals are quartz, calcite, epidote, and chlorite. The ores that have been shipped from this district carried considerable silver but only a small amount of gold.

The best-developed ore bodies of the district are those of the Ellamar and Beatson-Bonanza[1] mines. At the Ellamar the lode consists of a lens-shaped ore body, whose greatest horizontal dimension is 190 by 80 feet, occurring in a slate-graywacke series. The mine workings extend to a depth of 600 feet. The ore body consists of chalcopyrite, pyrite, and pyrrhotite, with some included masses of country rock. At the Beatson-Bonanza the ore occurs in a zone of hard greenish flinty rock which, for want of a better name, can be designated a hornfels, though its sedimentary origin has not been proved. This hornfels, which forms the country rock at the mine, occurs in a belt of slates and graywackes. The ore, which is chiefly chalcopyrite, occurs in fractures and as replacements in the hornfels. It is found disseminated in the hornfels and also as bands of nearly pure sulphides (chalcopyrite, pyrite, and pyrrhotite), which are in general parallel to the bedding of the slates and graywackes. Some

[1] Formerly called the Bonanza, but not to be confused with the mine of that name in the Chitina region.

faulting has taken place since the ore was deposited. Some basic dikes are present.

Among the deposits differing from those described above may be mentioned one occurring on Knight Island and near Mummy Bay, in which a coarse-grained diabase has been heavily charged with pyrrhotite and chalcopyrite. Another type, which is found on Orca Bay, is made up of epidotized stringers which occur in a crushed amygdaloidal basalt. These stringers carry native copper, chalcopyrite, bornite, and chalcocite in a gangue of quartz and epidote. In a few localities there are some well-defined fissure veins filled with quartz, pyrrhotite, pyrite, and chalcopyrite.

While these deposits have not been traced to the mineralizing influence of igneous rocks, yet Grant and Higgins have pointed out that certain basic intrusives are later than the shear zones and that the ores may bear a genetic relation to these rocks. Copper-bearing lodes of similar geologic occurrence have been found in the eastern part of Kenai Peninsula.[1]

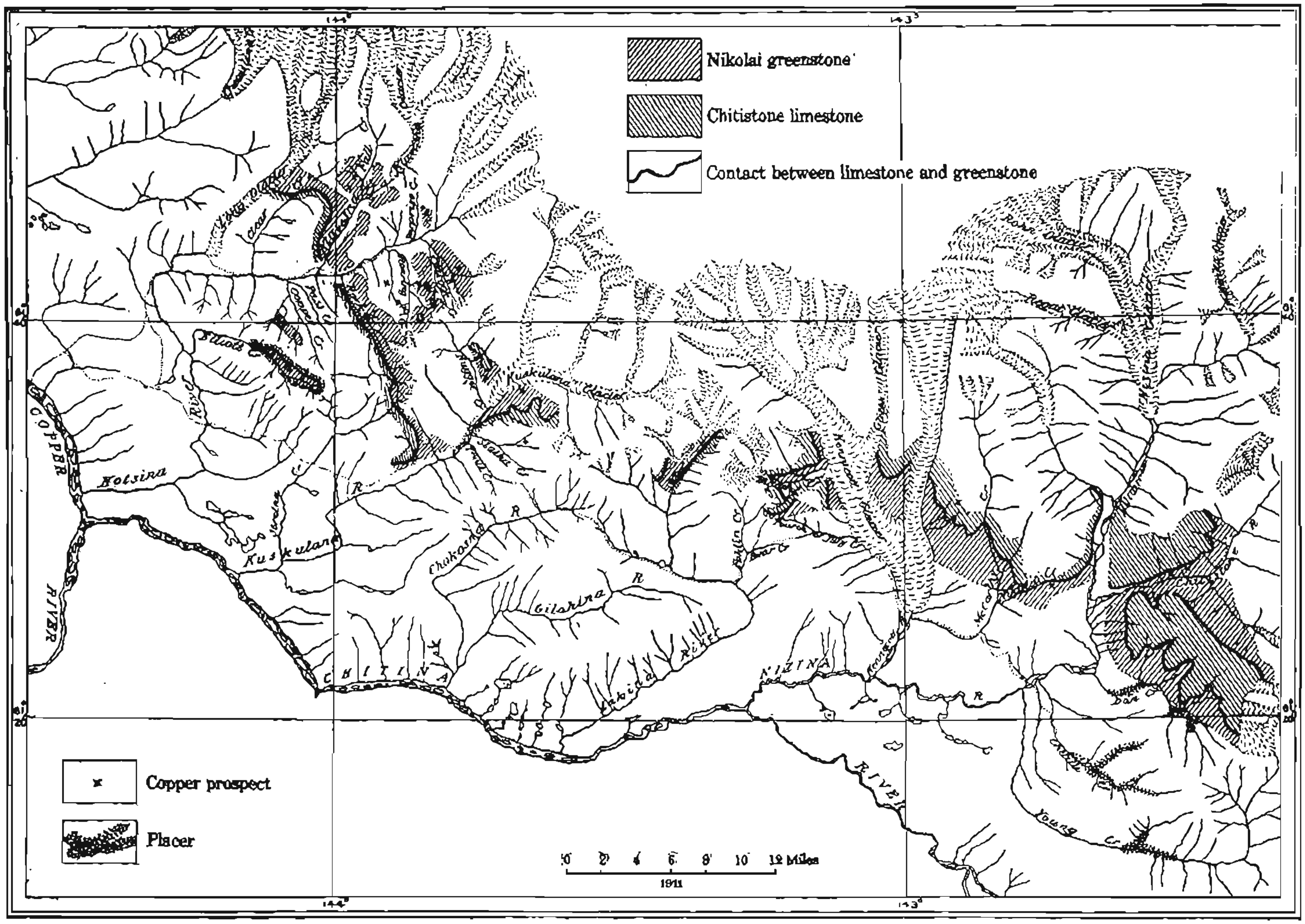
COPPER-BEARING LODES IN ASSOCIATION WITH GREENSTONES AND LIMESTONES.

The copper deposits which stretch along the southern flank of the Wrangell Mountains, in the Kotsina-Chitina district, have been investigated by a number of geologists,[2] but most of the following account is based on the observations and deductions of Moffit. With regard to copper resources, two formations of this field are of first importance. The older comprises a great sequence of ancient basaltic lavas, some of which are amygdaloidal, with which some sedimentary beds are intercalated. This series aggregates at least 3,000 to 4,000 feet in thickness and is called the Nikolai greenstone. This is conformably overlain by the Chitistone limestone, of Triassic age, made up of heavily bedded bluish-gray limestone aggregating 3,000 to 4,000 feet in thickness. The contact between these two formations forms the locus of the most important ore bodies which have yet been developed (see map, Pl. VI), but some copper occurs throughout the greenstone and copper lodes have been found in the limestone a long distance from the contact. The largest ore bodies so far found are those occurring within the limestone and within a thousand feet of the greenstone contact.

The conditions favorable to the deposition of copper appear to have been determined chiefly by the readiness with which the mineral-bearing solutions could circulate. Therefore the openings developed

[1] Grant, U. S., and Higgins, D. F., Preliminary report on the mineral resources of the southern part of Kenai Peninsula: Bull. U. S. Geol. Survey No. 442, 1910, pp. 166–178.

[2] Schrader, F. C., and Spencer, A. C., Geology and mineral resources of a portion of the Copper River district, Alaska, a special publication of the U. S. Geol. Survey, 1907. Moffit, F. H., and Maddren, A. G., Mineral resources of the Kotsina-Chitina region, Alaska: Bull. U. S. Geol. Survey No. 374, 1909. Moffit, F. H., and Capps, S. R., Geology and mineral resources of the Nizina district, Alaska: Bull. U. S. Geol. Survey No. 448, 1911.



GEOLOGIC SKETCH MAP OF KOTSINA-CHITINA COPPER BELT.

By F. H. Moffit, 1907.

by faulting, jointing, and shearing, which gave opportunity for this circulation, constituted one of the prime requisites to the formation of ore bodies. The most promising deposits have been found along lines of movement which intersected the contact at different angles. It also appears that the plane of the contact between the two formations locally furnished passages for the solutions, even where no movement had taken place.

A few deposits which can be classed as fissure veins have been found, but most of them are more or less irregularly distributed and represent replacements of the country rock by materials brought in solution along openings, many of which were very minute, caused by deformation.

Most of the sulphide copper deposits within the greenstone thus far prospected consist of irregular masses and blebs of the ore, distributed along zones of fracture, and in many places do not appear to have well-defined walls. Bornite and chalcopyrite are the most common of the copper ores in the greenstone, but some promising chalcocite ore bodies have been found. The copper deposits within the greenstones usually include very little gangue. Some vein deposits have also been found in the greenstone, and their ores are also chiefly bornite and chalcopyrite with a gangue consisting mainly of calcite, with some quartz and usually epidote.

Moffit regards the native copper deposits that have been found in the greenstone of the Kotsina-Chitina belt as probably secondary and due to the reduction of sulphides or oxides. The most common types of these deposits are those in which grains and irregular and tabular masses of native copper are distributed through certain zones in the greenstones. These are most common in the amygdaloidal phases of the greenstone, and here many of the amgydules are filled with native copper. At several localities carbonaceous matter and copper oxide occur with these native copper deposits. Some of the alluvium carries a large amount of placer copper which appears to have been derived from deposits of this type. Much of this placer copper is in thin sheets as if derived from planes of jointing or foliation. Nuggets of placer copper weighing several hundred pounds are not uncommon, and one mass of native copper found on Nugget Creek weighed 2 or 3 tons.

The most important feature of the deposits in the limestone are summarized by Moffit and Capps [1] as follows:

Copper deposits in limestone were formed by replacement of the limestone as a whole by copper minerals in solutions circulating along fracture planes such as faults, shear zones, or joints. The copper minerals are chalcocite and bornite, accompanied by malachite, azurite, and in places covellite as alteration products. As a rule, the

[1] Moffit, F. H., and Capps, S. R., Geology and mineral resources of the Nizina district, Alaska: Bull. U. S. Geol. Survey No. 448, 1911, p. 79.

boundary between ore and country rock is distinct, although the form of the ore body itself may be very irregular. This is particularly true where the copper mineral is chalcocite. In deposits of bornite in limestone a dissemination of the copper mineral through the adjacent country rock was noticed, and in such examples there is a gradation from ore to country rock similar to that in the greenstone deposits. One of the best examples of this kind shows a large proportion of chalcocite associated with the bornite, and the deposition of the copper was accompanied by a thorough silicification of the limestone. Large masses of chalcocite like that of the Bonanza property are distinctly replacement deposits in fracture zones. No fragments of limestone are included in the body of the ore, although isolated masses of chalcocite are scattered through the limestone. The ores are most frequent near the limestone-greenstone contact, yet some of them must be fully 1,000 feet above the base of the limestone. It is a notable fact that azurite is far more common as a secondary oxidation product in

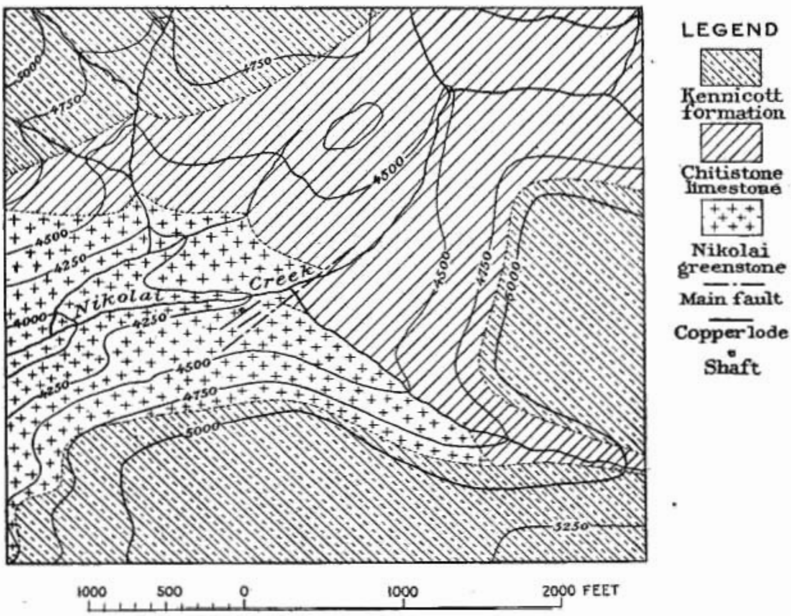


FIGURE 12.—Geologic sketch map of Nikolai Creek, Copper River region, showing relation of copper lodes to fault zone and to limestone-greenstone contact. By F. H. Moffit and S. R. Capps, 1909.

the limestone replacement deposits than malachite and that it is not common in the deposits in greenstone. Small veins of azurite with cores of chalcocite show distinctly that the azurite in the Bonanza mine was produced by the alteration of chalcocite. Covellite originated in a similar manner.

The Nikolai copper property, located on a tributary of McCarty Creek, affords an example of the vein type of deposit in the greenstone. It lies in a fault zone which intersects and offsets the limestone-greenstone contact. (See fig. 12.) The vein has been traced horizontally within about 400 feet of this faulted contact, though its nearest point to the limestone is only about 50 feet distant. According to Moffit the deposit is in part a replacement of the greenstone, in part a filling of a preexisting fissure. Chalcopyrite is the principal copper mineral, but with it is considerable bornite. With these are associated calcite, epidote, and quartz as gangue minerals.

At the Bonanza mine is the largest and best-developed ore body of the district. The mine is located at an altitude of about 6,000 feet,

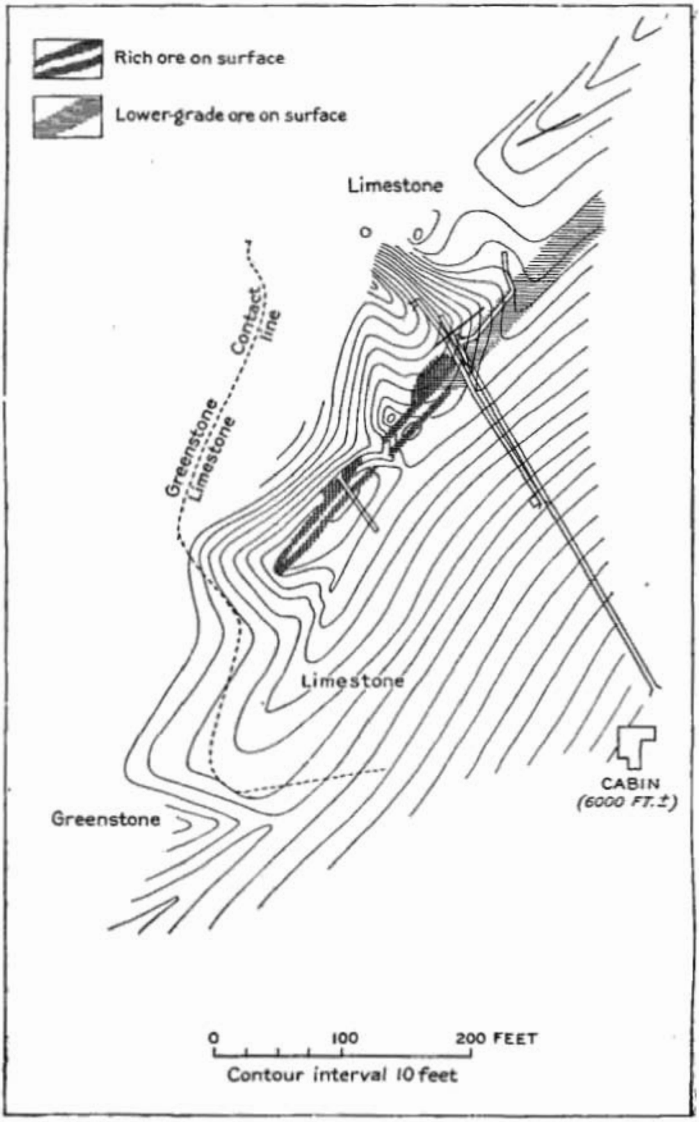


FIGURE 13.—Sketch map of the vicinity of the Bonanza mine, Copper River region, showing relation of copper deposits to limestone-greenstone contact. By F. H. Moffit and S. R. Capps, 1909.

near the crest of the ridge which separates the drainage of upper Kennicott River from McCarty Creek. The deposit includes bodies of chalcocite, which occur in a zone of fracture traversing the limestone and trending northeastward, in which direction it has been traced for about 1½ miles. The limestone-greenstone contact, which is about 40 feet from the nearest point on the ore body, is not offset by the fault but has been subjected to some minor displacements. (See fig. 13.) The zone of fracture has been affected by more than one line of movement. In the sheeted zone formed by this faulting, which is from 50 to 60 feet wide, occur the copper deposits, which range from small, irregularly distributed masses of copper to large, well-defined veins. The deposit appears to end above the limestone-greenstone contact, but a little mineralization is observable in the greenstone.

The ore is chalcocite, and but little else is included in the deposit. Azurite has been formed as an oxidation product, and some covellite is also present.

It is a significant fact that promising deposits of similar character occur on the extension of this zone of fracture on the McCarty Creek side of the divide and have been prospected. There appears, however, to be a barren area along the fracture zone between the Bonanza and the deposits on McCarty Creek, but even here copper-bearing minerals are found in places.

No other copper deposits have been developed in Alaska which are similar in association to those of the Kotsina-Chitina region. There are, to be sure, copper lodes in limestone and in greenstone in different parts of the Territory, but in none of these are the conditions of occurrence exactly similar to these described above. Some of the copper deposits of the White and Nabesna River regions occur in limestone, but these are for the most part in the contact zones of intrusive rocks [1] and have already been described. There are also some deposits in the ancient volcanic rocks of this northern field which may prove to be similar to those in the greenstone of the Chitina Valley. On the whole, however, the deposits of the two copper belts on the north and south sides of the Wrangell Mountains appear to be dissimilar in occurrence and genesis.

COPPER-BEARING AMYGDALOIDS.

Primary native copper has been found by Moffit and Knopf [2] in the upper White River basin and constitutes the only occurrence of this kind known in Alaska. The property containing this deposit, called the Copper King claim, is located at the head of the Middle Fork of White River. The country rock is a series of basaltic flows, breccias, and tuffs of Carboniferous age. To quote from Moffit and Knopf's report:

> Native copper is apparently limited in its occurrence to a certain definite volcanic sheet—a reddish lava that is locally amygdaloidal to a high degree. For 200 feet

[1] Moffit, F. H., and Knopf, Adolph, Mineral resources of the Nabesna-White River district, Alaska: Bull. U. S. Geol. Survey No. 417, 1910, p. 54.

[2] Idem, pp. 55-56.

along the outcrop of this sheet metallic copper intergrown with prehnite, calcite, and zeolites can be found here and there in encouraging amounts. The cupriferous portion of the amygdaloid appears to be about 6 feet thick, but as almost no development work has been done on the property [1908], figures of this kind have little value. The copper occurs as irregular reticulating masses of metal several inches long and as small lumps and minute particles embedded in the minerals that fill or line the former vesicles in the lava flow. In places these minerals either ramify in small veinlets through the body of the rock surrounding the amygdules or form irregular masses, and such places are eminently favorable for metallic copper.

These deposits are considered primary in the sense that the copper was deposited in the amygdaloidal or native state and is not the result of oxidation of sulphides, as is believed to be the case in the copper-bearing amygdaloid of the Nikolai greenstone.

SILVER, LEAD, AND ZINC.

Practically all the gold deposits and many of the copper deposits carry more or less silver. Galena, as has been shown, is not uncommon as an accessory mineral in these deposits. There are also some lodes in Alaska which are regarded as valuable because of their silver and lead contents. These nearly always carry also some subordinate gold values. Argentiferous galena-bearing fissure veins [1] have been developed on the south arm of Cholmondeley Sound—an indentation on the east side of Prince of Wales Island, in the Ketchikan district. These veins cut across both schists and limestone. According to the Wrights, where they crosscut the limestones they are replacement deposits. These veins carry galena, with a small amount of chalcopyrite and sphalerite, in a gangue of quartz, siderite, and calcite. Another group of galena deposits occurs about 12 miles east of Wrangell, in southeastern Alaska.[2] Here there is a slate-schist belt about a mile wide lying between granite areas. These altered sediments are traversed by acidic porphyry and aplite dikes, and in these or along the contacts the galena deposits occur. The deposits are fissure veins, which appear to be persistent. They are heavily mineralized with galena, sphalerite, pyrite, and chalcopyrite.

Some galena deposits [3] have also been opened on Coronation Island, which lies near the entrance to Chatham Strait, in southeastern Alaska. The bedrock of the island, so far as known, consists of Paleozoic limestones and schists, which have been intruded by granite. The ore deposits are irregular masses within a limestone country rock. Besides the galena, tetrahedrite and sphalerite are present in the ores.

Among the many localities where galena ore deposits have been found in Alaska, that in the Fish River basin, in the eastern part

[1] Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska: Bull. U. S. Geol. Survey No. 347, 1908, pp. 187-188.

[2] Idem, pp. 188-190.

[3] Idem, pp. 190-191.

of Seward Peninsula, deserves mention. One of the first attempts at lode mining in Alaska was at this locality, at the Omilak mine, in 1882. According to Smith and Eakin,[1] the country rock consists of crystalline limestone and schists and also some more or less schistose igneous rocks which are classed as greenstones. The galena ores occur in a zone of fracture in the limestones, near the contact with some of the schistose greenstones. Within this zone they are irregularly distributed in masses and blebs. The galena carries gold and a large amount of silver.

Some galena deposits have also been found in the western part of Seward Peninsula, in the Lost River and Brooks Mountain regions.[2] These occur in shattered zones which traverse limestones of early Paleozoic age. Some of them are clearly contact-metamorphic deposits of granite and limestone; others are more or less intimately associated with quartz porphyry dikes.

No deposits valuable for their zinc contents have been found in Alaska. As has been noted in the preceding pages, sphalerite is a common accessory mineral in the gold, silver, and some of the copper deposits.

TIN AND TUNGSTEN.

Cassiterite in the form of stream tin is not an uncommon mineral in the auriferous gravels of the Yukon-Tanana region and Seward Peninsula, but its only known occurrences of possible commercial value are limited to the York region, in the western part of Seward Peninsula. Stream tin, however, forms a considerable percentage of the concentrates from the sluicing operations on some of the placer mines on tributaries of Patterson Creek, in the Hot Springs district, of the Tanana Valley. Considerable stream tin, associated with wolframite, has also been found on Deadwood Creek,[3] in the Birch Creek district. Scheelite, another tungsten mineral, has been found both in some of the auriferous gravels and in some small quartz veins on Seward Peninsula.

The only lode-tin deposits of which there is definite knowledge are those found in the western part of Seward Peninsula. Contributions to the knowledge of these lode and placer tin deposits have been made by several geologists,[4] but the following statements are

[1] Smith, P. S., and Eakin, H. M., A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region: Bull. U. S. Geol. Survey No. 449, 1911, pp. 130-133.

[2] Knopf, Adolph, The mineral deposits of the Lost River and Brooks Mountain regions of Seward Peninsula: Bull. U. S. Geol. Survey No. 345, 1908, pp. 268-271.

[3] Johnson, B. L., Occurrence of wolframite and cassiterite in the gold placers of Deadwood Creek, Birch Creek district: Bull. U. S. Geol. Survey No. 442, 1910, pp. 246-250.

[4] Brooks, A. H., A new occurrence of cassiterite in Alaska: Science, new ser., vol. 13, No. 328, p. 593; A reconnaissance of the Cape Nome and adjacent gold fields of the Seward Peninsula, Alaska, 1900, a special publication of the U. S. Geol. Survey, 1901, pp. 132-139. Collier, A. J., A reconnaissance of the northwestern part of Seward Peninsula, Alaska: Prof. Paper U. S. Geol. Survey No. 2, 1902, p. 49; Tin deposits of the York region, Alaska: Bull. U. S. Geol. Survey No. 229, 1904. Hess, F. L., The York tin region: Bull. U. S. Geol. Survey No. 284, 1906, pp. 145-157. Knopf, Adolph, Geology of the Seward Peninsula tin deposits: Bull. U. S. Geol. Survey No. 358 1908.

based almost entirely on the report of Knopf, who has made a more exhaustive study of this field than anyone else.

The York region, as here defined, comprises an area about 50 miles in width, including the west end of Seward Peninsula. A series of more or less altered argillitic slates, which contain much arenaceous material, comprise the oldest rocks of the field. (See

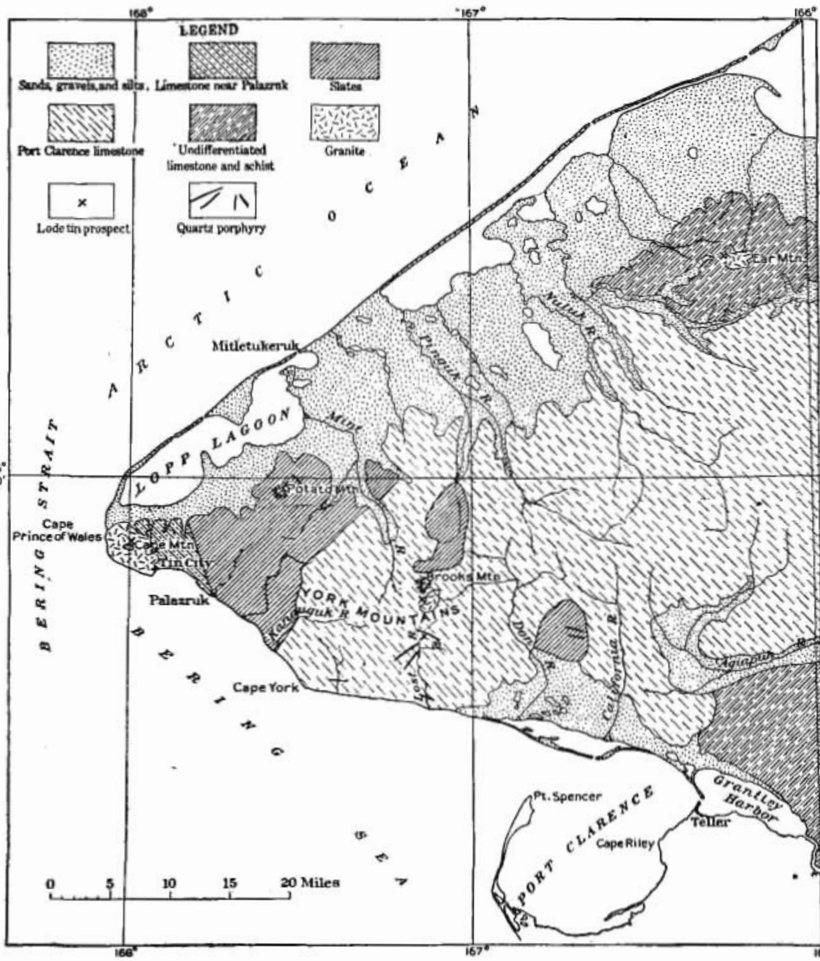


FIGURE 14.—Geologic sketch map of west end of Seward Peninsula, showing relation of tin deposits to intrusive rocks. By Adolph Knopf, 1907.

fig. 14.) These appear to be overlain on the east by heavy unaltered limestones of early Paleozoic age. On the west they are faulted against some crystalline limestones and schists, which are of Carboniferous age. Greenstones occur in the slates, and granites and quartz porphyry dikes cut all the formation. Knopf[1] summarizes

[1] Op. cit., p. 64.

the different types of cassiterite-bearing lodes, which in the slates are genetically related to intrusive granites, as follows:

1. In a tourmaline-axinite hornfels.
2. In beds of actinolite rock which are probably interstratified with slates.
3. In tourmalinized margins of granite masses and granitic dikes.
4. In mineralized quartz porphyry dikes.
5. In quartz veins cutting granite and accompanied by impregnation of the adjoining granite.
6. In quartz stringers cutting slates and limestones.

These deposits carry a large number of mineral species, which it is not worth while to enumerate here. Among the tungsten minerals wolframite and scheelite are worthy of note.

The cassiterite and wolframite of the alluvium in Deadwood Creek have been traced by Johnson[1] to a granite-schist contact zone, and prospectors report a small vein carrying these minerals in the vicinity. Johnson has listed the following minerals as occurring in the concentrates from this alluvium: Wolframite, cassiterite, magnetite, ilmenite, arsenopyrite, pyrite, galena, limonite, garnet, tourmaline, and quartz. The other creeks in the Yukon-Tanana region which have yielded stream tin all lie in areas of granite intrusions.

IRON.

In the absence of any development of the coking coals and the lack of transportation, there has been little encouragement to prospect Alaska's iron ores. Therefore there are few data on which to base conclusions regarding their geologic occurrence. Three types of iron-ore deposits have been recognized—(1) iron ores lying in the zones of igneous metamorphism, due to intrusion and to be classed as contact ores; (2) vein deposits; (3) deposits of magmatic segregations. The occurrence of magnetite in the contact zones of limestones and other sediments and intrusive rocks has already been noted in the description of the copper deposits with which these iron ores are associated (pp. 74–79). The best known of this type of magnetite deposits are those of Prince of Wales Island. Of these occurrences the Wrights[2] say:

> At the copper mines in Kasaan Peninsula magnetite forms about half of the ore mass and occurs in large amounts in some of the deposits in the vicinity of Hetta Inlet. * * * At several places on Prince of Wales Island magnetite occurs in masses sufficiently high in grade to make an iron ore, though no attempt has been made to mine it as such.

No analyses are available of these magnetite ores, but similar types of deposits have been mined on Tuxedo Island, in British Columbia,

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[1] Johnson, B. L., Occurrence of wolframite and cassiterite in the gold placers of Deadwood Creek, Birch Creek district: Bull. U. S. Geol. Survey No. 442, 1910, pp. 246–250.

[2] Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska: Bull. U. S. Geol. Survey No. 347, 1908, p. 89.

and these have an average of 55 to 60 per cent of metallic iron,[1] while the phosphorus content of most of them is low enough to make them fall within the Bessemer limit. The sulphur content, however, is high. Magnetite occurs in similar geologic association on Prince William Sound, in the Iliamna region, and in the Nabesna region, as well as elsewhere in Alaska.

So far few examples of the vein type of iron deposits have been found. Schrader[2] described a magnetite ore body which appears to be a vein in the Nabesna region. This vein is well defined and occurs at a contact between limestone and diabase. Grant and Higgins report the occurrence of hematite and magnetite bearing veins in the Prince William Sound region.

Iron-ore deposits of the segregated type occur near Haines, in southeastern Alaska, but their commercial value remains to be established. These, according to Knopf,[3] consist of primary magnetite disseminated in a basic rock composed of pyroxene and hornblende. The best specimens seen carried a maximum of 30 per cent of magnetite. A microscopic examination showed the presence of apatite and the analysis of one sample showed 3.91 per cent of TiO_2.

Chromite occurs near Port Chatham, on Kenai Peninsula.[4] The country rock is a peridotite, composed essentially of olivine, which contains small grains of chromite. In places the chromite is abundant and is segregated in small bands, and these form the ore deposits.

ANTIMONY.

Stibnite, the sulphide of antimony, is one of the most widely distributed ores in Alaska. As has been noted, it occurs as an accessory mineral in many of the ore bodies of types already described. It remains to give an account of the occurrence of stibnite-bearing lodes in which the stibnite is the dominating metallic mineral. In all these occurrences the stibnite-bearing lodes carry more or less gold, and a number of them probably carry enough gold to warrant classifying them with the auriferous lodes.

In southeastern Alaska stibnite has been recognized only as an accessory mineral in some of the gold ores. Grant and Higgins[5] have described an occurrence of stibnite on Port Wells, Prince William Sound. At this locality there is a zone of brecciation along a fault

[1] Lindeman, Eimar, Iron-ore deposits of Vancouver and Tuxedo Islands, British Columbia: Pub. No. 47, Canada Dept. Mines, Mines Branch, Ottawa, 1910.

[2] Mendenhall, W. C., and Schrader, F. C., Mineral resources of the Mount Wrangell district, Alaska: Prof. Paper U. S. Geol. Survey No. 15, 1903, pp. 65–66.

[3] Knopf, Adolph, The occurrence of iron ore near Haines: Bull. U. S. Geol. Survey No. 442, 1910, pp. 144–146.

[4] Grant, U. S., and Higgins, D. F., Preliminary report on the mineral resources of Kenai Peninsula: Bull. U. S. Geol. Survey No. 442, 1910, pp. 168–169.

[5] Grant, U. S., and Higgins, D F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: Bull. U. S. Geol. Survey No. 443, 1910, p. 78.

line which cuts across the country rock of black slate and graywacke. These sediments are cut by acidic dikes in the vicinity. The stibnite ore occurs in a band of vein quartz along the hanging wall of the shear zone. No other minerals were noted in this deposit. Grant and Higgins [1] also report the occurrence, near Kenai Lake, north of Seward, of a fine-grained sheared acidic dike which contained particles and stringers of stibnite. Of the stibnite in the Fairbanks district Prindle [2] says:

> Stibnite was common in the concentrates from the placers in the early days of mining in the Fairbanks district and was afterward found in place in the bedrock at several localities in widely different parts of the district. It occurs in place here and there in the drainage area of Cleary Creek, and, together with arsenopyrite, accompanies the gold in the richest of the quartz veins. It has been found as narrow stringers composed almost entirely of massive stibnite crosscutting quartzite schist or forming a network of stibnite veins between fragments of brecciated schist; in veins of quartz and stibnite, where the massive stibnite occupies the spaces left between quartz crystals; and as fine needle-like crystals or small crystalline groups along with some fresh, clear quartz areas in more or less fractured quartz veins. At one locality stibnite was found in close association with a sericitized dike of granite porphyry. The schist had not only been intruded by the dike but had apparently been fractured by it. Stibnite has been deposited on the surface of the dike and occurs as small veins and lenticular masses up to several pounds in weight in the schist. The stibnite at this locality is apparently in close genetic association with the granite porphyry.

A ledge carrying stibnite has also been found on Caribou Creek, in the Kantishna district.[3] Here the stibnite is intergrown with quartz in a vein lying parallel to the foliation of the country rock, which is a hornblende schist. Antimony-bearing ledges are known to have been found on Seward Peninsula, in the Nome River basin and on upper Fish River. On Manila Creek, a tributary of Nome River, there is a well-defined quartz vein through which stibnite is disseminated. The country rock is schist, but the vein occurs near a limestone-schist contact.[4] At the Omilak mine,[5] in the Fish River basin, stibnite occurs in a shattered zone in a limestone bedrock. This limestone, which forms a belt almost one-fourth of a mile wide, bounded on both sides by schist, is cut by an altered intrusive rock.

OTHER METALLIC MINERALS.

Nickel and cobalt deposits have been reported by prospectors, but in no samples tested by the Survey were these metals found in commercial quantities. A small amount of nickel and traces of cobalt were found by the analyses of some pyrrhotite ores from the Ketchi-

[1] Grant, U. S., and Higgins, D. F., Preliminary report on the mineral resources of the southern part of Kenai Peninsula: Bull. U. S. Geol. Survey No. 442, 1910, p. 178.

[2] Prindle, L. M., Auriferous quartz veins in the Fairbanks district: Bull. U. S. Geol. Survey No. 442, 1910, p. 221.

[3] Prindle, L. M., The Bonnifield and Kantishna regions: Bull. U. S. Geol. Survey No. 314, 1907, p. 219.

[4] Moffit, F. H., The Nome region: Bull. U. S. Geol. Survey No. 314, 1907, p. 139.

[5] Smith, P. S., and Eakin, H. M., A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region: Bull. U. S. Geol. Survey No. 449, 1911, pp. 64–131.

kan district.[1] Similar tests on pyrrhotite ores from Prince William Sound revealed neither cobalt or nickel.

No commercial bodies of molybdenite have been found. In the Juneau district this mineral is found in some of the auriferous deposits which occur in the dioritic rocks, notably at the Treadwell mine. Molybdenite has also been found in quartz stringers which cut the sediments altered by igneous metamorphism adjacent to the Coast Range granite belt in the Ketchikan district. It has also been seen as an accessory mineral with the gold ores in other parts of Alaska.

A deposit of native bismuth on which a little development work has been done occurs on Charley Creek, tributary to Sinuk River, about 25 miles north of Nome. The bismuth occurs in two small quartz veins cutting a schist bedrock.

A cinnabar deposit was discovered near Kolmakof, on the Kuskokwim, many years ago and is a perennial source of attraction to prospectors. This deposit has not been studied by members of the Survey. Spurr,[2] however, notes that these veins cut shales of Mesozoic age, which have been intruded by acidic dikes. Cinnabar is found as an accessory mineral in some of the auriferous gravels. This mineral is very abundant in the concentrates from placer mining on Daniels Creek, about 60 miles east of Nome. While the bedrock source of this cinnabar has not been found, it evidently lies close at hand in a contact zone of schist and limestone.

A few minute grains of platinum have been found in some of the Alaskan gold placers, but nowhere in sufficient quantity to be of commercial importance.

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[1] Wright, C. W., and F. E., The Ketchikan and Wrangell mining districts, Alaska: Bull. U. S. Geol. Survey No. 347, 1908, p. 87.

[2] Spurr, J. E., A reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 261-262.

MINING IN SOUTHEASTERN ALASKA.

By Adolph Knopf.

INTRODUCTION.

Southeastern Alaska has long held the world's record for the production of low-grade gold ore, a position due in the past mainly to the output of the Treadwell group of mines on Douglas Island. These mines are operating on a mineralized dike of albite diorite—a type of ore body of which this is so far the only one exploited in the region. On the mainland there exist behind the town of Juneau enormous bodies of low-grade ore, consisting of slate irregularly cut by auriferous quartz stringers. Mines have been operating on these ore deposits at a profit for a number of years, and the mining and milling costs have even been brought below those existing at Treadwell, but because of the disadvantageous situation of the mines several miles from tidewater the ore bodies have never been exploited on a scale commensurate with their magnitude. Plans have been formulated for their extensive development, but the execution of these large projects has necessarily been slow. Construction, however, was actually started in the later part of 1910, and it now appears that several hundred additional stamps will be dropping in the Juneau region in 1912. It is safe to say that, with this increase of milling capacity and the new developments contemplated or in progress at Douglas Island, Berners Bay, and Chichagof the gold production of southeastern Alaska will at least be doubled within a few years.

In contrast to this marked expansion of the gold-mining industry the copper-mining industry shows a stationary condition, nor with the prevailing low price of the metal is there likely to be any greatly increased output of ore.

Marble continues to attract attention as one of the mineral resources of southeastern Alaska. Prospecting continues and claims are located at widely separated localities, as at Dall Island, on the west coast, and at Limestone Inlet, 25 miles south of Juneau, and the productive quarries are enlarging their capacity.

GOLD MINES AND PROSPECTS.

PRODUCTION.

According to preliminary estimates, the production of gold for 1910 in southeastern Alaska was substantially the same as that for 1909, in round numbers $4,000,000. The following table gives the tonnage and value for a number of preceding years. It shows clearly the preponderant influence of the low-grade ores of the Juneau district on the average value per ton:

Production of gold ore in southeastern Alaska.

Year.	Ore mined.	Gold.		Silver.		Average value per ton.
		Amount.	Value.	Amount.	Value.	
	Tons.	*Ounces.*		*Ounces.*		
1907	1,206,639	132,300	$2,734,885	22,203	$14,653	$2.28
1908	1,475,516	161,975	3,348,312	31,834	16,872	2.28
1909	1,478,429	198,285	4,098,900	27,481	14,290	2.78

JUNEAU AND BERNERS BAY REGIONS.

DOUGLAS ISLAND.

The steadily increasing depth from which ore is extracted at the Treadwell group of mines has made advisable an enlargement of the hoisting capacity. In order to realize the economies of a central hoisting plant, it has been decided to make the shaft of the 700-foot claim the main hoisting shaft of the three mines that are grouped on the same lode—the Alaska-Treadwell, the 700-foot, and the Alaska-Mexican. A contract has been let for a balanced hoist capable of lifting 5,000 tons from a depth of 3,000 feet in 20 hours, the net load being 8 tons. A new gallows frame will be erected and new crushing machinery of heavier capacity installed. It is anticipated that the entire plant will be ready for operation by the fall of 1911.

The hydroelectric plant at the mouth of Sheep Creek, which is capable of generating 2,500 horsepower for about two-thirds of the year, and the transmission line to Treadwell were completed during the year. Work was started on a transmission line from Treadwell to Nugget Creek at Mendenhall Glacier, a distance of 12 miles, where it is proposed to build a dam, probably 125 feet high, which will have a storage capacity equivalent to approximately 5,000 horsepower for 90 days. When this project is completed, it will be possible to run the 300-stamp mill of the Alaska-Treadwell the entire year. At present it is shut down during the winter months on account of lack of water power.

Pelton wheels have been installed at the Ready Bullion and Mexican mills, and the stamps are now operated by water power developed from the Ready Bullion dam.

A thoroughly equipped cyanide plant, capable of handling 100 tons of concentrates a day, has been completed and will render shipment of the sulphurets to the smelter unnecessary in the future.

At the Alaska Treasure mine, on Nevada Creek, 3,100 feet of the projected 3,500-foot double-track tunnel has been completed. A rate of 50 to 76 feet a week is attained and the ore body will doubtless be undercut before this report goes to press. No extensive surface improvements have yet been undertaken, pending underground development of the ore body.

GOLD CREEK MINES.

The mines situated in Silverbow Basin, at the head of Gold Creek, operate at a maximum only six months in the year. As winter approaches, freezing weather sets in, water runs low, and the mills, which are operated by water power, are necessarily shut down. To remedy this it has been proposed to build new mills at tidewater on Gastineau Channel, where they could be operated the year round. Haulage tunnels from 10,000 to 13,000 feet long would be required to bring the ore to the mills, but although these plans have been under consideration for several years, little has been done toward their accomplishment. A partial fulfillment, however, seems likely during 1911.

Mining was resumed at the Perseverance mine on May 25. A force of 110 men were employed and the 100-stamp mill was in operation during the season.

The Alaska-Juneau started up on June 4, employing 30 men. Most of the ore extracted during the year came from the upper pit. It was stated by the managers that a 6,000-foot tunnel would soon be driven from Snowslide Gulch, undercutting the ore at a depth of 600 feet; from the portal of the tunnel the ore would be taken by a surface tram to tidewater below the town of Juneau, where a stamp mill of 23,000 tons capacity per month is to be erected.

On the Ebner property the California & Nevada Copper Co. commenced work on a new 200-stamp mill. Framed timbers, mortars, and other equipment were landed at Juneau, and late in the fall grading was commenced on the mill site near Shady Bend, on the road from Juneau to Silverbow Basin.

OTHER MINES AND PROSPECTS.

The several mines and prospects at Berners Bay lay idle during 1910, but it is confidently expected that they will be opened in 1911 on a scale commensurate with their magnitude and importance.

There was little activity in the region lying between Berners Bay and Eagle River, to the south. At Amalga the Eagle River mine operated 10 stamps intermittently during the year. Exploration work was continued in the endeavor to find the extension of the lode in unbroken and undisturbed ground, and late in the year it was reported that ore had been found in solid bedrock.

At the Mitchell & McPherson prospect, which is situated on the northwest flank of Thane Mountain between Eagle and Herbert glaciers, a new tunnel projected to undercut the ore body 100 feet vertically below the lowest outcrop was commenced at a position secure from the rock slides that endangered the older workings. Thirty-five feet of tunnel was completed.

Considerable development work was done on the Peterson group of claims on Peterson Creek with a view to test the property adequately. A 4-mile planked horse tramway was built from Pearl Harbor to the camp on the Prairie claim, a 500-foot crosscut tunnel was started, and a diamond drill was acquired, with which it was proposed to put down six 500-foot holes to determine the behavior and value of the ore body in depth.

On the Dull & Stephens prospect near Auke Bay a large body of low-grade quartz has been exposed by stripping the overburden of moss, vegetation, and glacial clay and gravel, which was hydraulicked off by booming. Work was in progress during the early part of the year under a bond but was suspended in August.

Extensive croppings of quartz have been uncovered near Treasury Hill, a few miles from Auke Bay, but owing to negotiations concerning the sale of the property no important development work was undertaken during 1910.

There was little activity in the gold belt south of Juneau. At the Crystal mine, at Port Snettisham, operations were suspended in September and the mill was closed. The ore body consisted of a quartz fissure vein averaging 4 feet in thickness, inclosed in a country rock of zoisite amphibolite probably derived from an andesite porphyry and dipping 10° to 40° NE. In recent years the ore has been extracted by tunnels drifted on the vein at successively higher levels.

At Limestone Inlet the main work has been done on a prospect known as the Enterprise, which is situated at an altitude of 1,370 feet. The country rock is a somewhat porphyritic quartz diorite, which is intrusive into a series of old volcanic rocks exposed along the north shore of the inlet. The ore body consists of a sheeted quartz vein striking N. 20° E. and dipping 45° W. The walls are well defined and the vein ranges between 2 and 3 feet in thickness. The quartz carries coarse pyrite and galena and shows free gold, the ore averaging, it is said, $15 a ton for the whole ore body. The prospect has been developed by a drift tunnel 30 feet long and by stripping of the ledge along the outcrop for several hundred feet.

SITKA AND KETCHIKAN MINING DISTRICTS.

The only active gold mines in the Sitka district are the Chichagof (locally known as De Groff) and Golden Gate mines. They are situated at the head of Klag Bay, on the west coast of Chichagof Island, 50 miles north of Sitka. Both mines are operating on what is presumably the same lode and are extracting a comparatively high-grade ore. The De Groff mine and mill are situated near sea level and the Golden Gate mine at 1,000 feet altitude, but the mill has been built at tidewater.

At the De Groff mine the present milling plant, consisting essentially of two batteries of two 850-pound stamps each and an edge-runner mill of the Chili type, proved to be inefficient and subject to vexatious delays, and in consequence it was decided to erect a new 10-stamp mill with heavier stamps and standard equipment. The ore milled during the year came from the rich ore shoot developed by the raise from the adit level to the upper tunnel; this ore was found to have a greater strike length than was indicated by the earlier workings.

On the Golden Gate property the stamp mill and aerial tram were completed and the milling of the ore commenced. The mill has been built for 10 stamps, but only 5 have been installed. The ore milled was mainly that which had accumulated on the dump during the early development of the mine and was rather medium or low grade. Underground development was continued, and an ore shoot comparable in value to those of the De Groff mine was reported to have been encountered late in June.

In the Ketchikan district several hundred feet of tunnel were driven on the proposed 1,600-foot crosscut tunnel at the Lon-de-Van group, which is situated on the north shore of George Inlet. This tunnel, which commences at the beach, is projected to undercut the ore body exposed at 900 feet above sea level.

Development continued on the Julia claim at Hollis until September, when the mine was shut down. Late in the year a small force of men was put to work on the Goldstream property on Gravina Island, 3 miles from Ketchikan, with a view to reopening the property. The main work done consisted of drifting on the 50-foot level. It is proposed to conduct experimental treatment of the ore to find a process that will give an economic extraction of the values, which have hitherto proved not readily amenable to ordinary stamp-milling practice.

COPPER MINES AND PROSPECTS.

GENERAL STATEMENT.

During 1910 copper ore was shipped from four mines, three of which are situated on Kasaan Peninsula and one on Hetta Inlet. They are all on Prince of Wales Island, in the Ketchikan mining district.

The main productive properties, as is well known, are located upon contact-metamorphic ore bodies, which commonly occur at or near the contact of limestone with intrusive masses of dioritic rocks. The ore is confined to the limestone and occurs in deposits of irregular shape and value. Many of the bodies are rich, consisting of masses of nearly solid copper mineral. These are easily exploited and a considerable tonnage of high-grade ore is rapidly extracted. They are then found to be surrounded on all sides by barren gangue material consisting either of magnetite, or crystalline limestone, or masses of lime silicates such as garnet, epidote, and pyroxene. The problem is then to find more ore. Inasmuch as the ore masses are without walls or other features that usually serve as guides in the search for new ore, the problem is difficult and no consistent or systematic method of development work has yet been evolved. At two of the mines diamond drills have now been installed to expedite the exploration for more ore.

A fear seems to exist in the district that ore will not persist in depth. Exploration work has been mainly in the lateral directions at comparatively shallow depths. Deeper development has perhaps been retarded by the apprehension that the ore will not go down. This fear appears to the writer to be groundless. It should be borne in mind, however, that although the ore bodies are likely to persist downward their distribution within the ore-bearing zone will be as irregular and erratic in depth as it is in the upper levels. This is no peculiarity of the Alaskan deposits but is common to all ore bodies of contact-metamorphic origin. Inasmuch as the primary sulphide chalcopyrite—the only cupriferous mineral in the ore—outcrops at the surface and, furthermore, as the origin of the ore bodies is independent of any relation to the existing topography, there is no reason to anticipate that the ores on the average will become richer in depth.

These deductions follow purely from the geologic evidence. The record of actual producing mines affords welcome data as to the possibilities of this type of ore deposit at increasing depth. On Texada Island, British Columbia, ore bodies of contact-metamorphic origin persist to a depth of at least 1,000 feet and the values in copper, gold, and silver hold in the bottom levels. At the Jumbo mine, on Hetta Inlet, in the region under discussion, the vertical range throughout which bodies of ore are known to occur exceeds 700 feet.

On the whole it can be said that the past record of the main producing mines on Prince of Wales Island shows that the masses of ore are encountered within the ore-bearing zone in sufficient number to maintain a profitable production; that this will continue in depth seems probable enough to justify in some mines a more systematic method of development than has yet been attempted. Extremely long adit levels that aim to undercut the ore-bearing zones at depths of more than several hundred feet, however, are inadvisable, on account of the proved capricious character of contact-metamorphic zones.

PRODUCTION.

The production of copper ore in southeastern Alaska during 1910, as shown by a preliminary estimate, is 2,250,000 pounds, which is less than that of 1909. The output for a number of preceding years is shown in the following table:

Production of copper ore in southeastern Alaska.

Years.	Ore mined.	Copper.		Gold.		Silver.		Average value per ton.
		Amount.	Value.	Amount.	Value.	Amount.	Value.	
	Tons.	*Pounds.*		*Ounces.*		*Ounces.*		
1907	79,982	4,758,814	$951,761	3,384	$69,960	44,196	$29,143	$13.14
1908	43,215	3,260,399	430,372	2,213	46,310	24,648	13,063	11.10
1909	28,491	2,705,988	351,778	1,946	40,228	16,679	8,641	14.06

KETCHIKAN MINING DISTRICT.

KASAAN PENINSULA.

The Mount Andrew mine, which is operating on a contact-metamorphic ore consisting essentially of chalcopyrite in a gangue of magnetite, maintained its usual annual production and in addition undertook some important new development work. The main supply of ore was obtained from stopes 2 and 4. Considerable drifting was done on the 50-foot level and good ore was encountered at several places. A raise was put through from this level to ore shoot No. 4, from which a large tonnage of rich ore has been extracted in the past and which is now being stoped downward from the main adit level, tunnel No. 1. A new tunnel, known as No. 2, was started several hundred feet northwest of No. 1, undercutting the outcrops at a depth of 100 feet, and enough ore was encountered to continue prospecting. The most noteworthy development work commenced during the year was that done on the new tunnel, designated No. 3, which, commencing at the old camp, is projected to undercut the ore body 300 feet below the present working level. The length will be 1,600 feet; 100 feet had been driven by the end of September.

At the It mine operations for the year commenced early in April. The main ore bodies lie in an embayment of limestone in an intrusive mass of diorite. The limestone has been coarsely recrystallized and more or less converted into lime-silicate rock. The ore consists of chalcopyrite in a gangue of calcite; the silicates, consisting of garnet, epidote, pyroxene, and others, contain only a small amount of copper mineral irregularly scattered through them. Development is proceeding on three levels below the working tunnel, the lowest being at a depth of 150 feet. From these levels the surrounding territory is being carefully prospected by diamond drilling.

At the Dean, a newly discovered prospect not far from the It mine, a tunnel 100 feet long was driven and a shallow winze was sunk 50 feet in from the portal. The ore is of typical contact-metamorphic type and consists of chalcopyrite in a gangue of coarsely crystalline pinkish calcite, associated with varying amounts of garnet, pyrite, and hematite. Several hundred feet northeast of this tunnel another has been driven approximately 75 feet long in a mass of lime-silicate rock.

Operations were resumed late in March at the Goodro mine after the winter shutdown. The main development undertaken consists of a winze sunk a depth of 100 feet below the tunnel. From the bottom of the winze drifts were driven both east and west and aggregate 150 feet in length. The winze is said to have been sunk in ore for 45 feet—that is, bornite in a heavy gangue composed essentially of pyroxene and biotite, with some feldspar and epidote. In the bottom level, which is 200 feet below the outcrop, some finely disseminated chalcocite and native copper were encountered. A width of 14 feet of this kind of ore is said to have been crosscut. All work was suspended after the middle of September, but it is planned that future exploration shall be done by diamond drilling. The discovery of chalcocite at a depth of 200 feet shows that the process of secondary sulphide enrichment has gone far deeper than would have been considered probable in this highly glaciated region. No such enrichment has affected the contact-metamorphic deposits, and this occurrence is therefore the more surprising.

HETTA INLET.

The only property on Hetta Inlet productive during 1910 was the Jumbo mine of the Alaska Industrial Co. This mine is the largest producer of contact-metamorphic copper ore in Alaska. The ore is mainly derived from the upper levels, in which there still remains a large amount of unexplored territory. In the stope on tunnel No. 4, the working tunnel and deepest level, a vertical diamond-drill hole was put down 130 feet and ore was encountered, proving that at this property the contact-metamorphic ore has a vertical range of at least 700 feet. On the level of tunnel No. 1 the ore-bearing zone is being explored southeastward by diamond drilling. A tunnel, projected to be 5,000 feet long and to undercut the ore bodies at 1,500 feet depth, has been started from tidewater, but work on it is not being pressed.

At the Red Wing mine it was reported that a crew of 12 men were employed in sinking a new shaft, planned to be 500 feet deep. This was the only other mining activity of note on Hetta Inlet during the year.

OTHER LOCALITIES.

At Big Harbor, near Klawak, on the west coast of Prince of Wales Island, the Northland Development Co. is said to be prospecting an ore body 62 feet wide and has driven an aggregate of 400 feet of drifts and tunnels. The ore was reported to consist of chalcopyrite in a lime gangue, but the samples shown to the writer proved to be a highly siliceous sericitic schist carrying disseminated chalcopyrite and pyrite. Some ore rich in black zinc blende was seen that came from the same locality.

At Seal Bay, on Gravina Island, the main crosscut tunnel has now attained a length of 1,700 feet, but driving ahead has been suspended. Eight quartz-chalcopyrite veins are reported to have been crosscut; at present the vein known as No. 3 is being drifted on and shows 5 feet of ore running 2 per cent in copper.

Late in the year a crew of six men was employed at the Rush & Brown mine, which is situated near the head of Karta Bay, on Prince of Wales Island. The mine was unwatered and preparations were made to get out a shipment of ore.

Development work continued at a number of other copper prospects scattered throughout the Ketchikan district, such as the Yellowstone group, on Dall Island; the Veta group, at Mallard Bay, near the south end of Prince of Wales Island, and others; but no operations of any considerable magnitude are to be recorded.

It is reported that work was resumed by a small force of men on the Moonshine vein, on the South Arm of Cholmondeley Sound. The values in this property are silver and lead, and it is one of the few of its class in southeastern Alaska.

THE EAGLE RIVER REGION.

By Adolph Knopf.

INTRODUCTION.

The Eagle River region as defined in this report embraces the portion of the Juneau gold belt extending from Berners Bay on the north to Salmon Creek on the south. A topographic map of this region on the scale of 1 mile to the inch was commenced by J. W. Bagley in 1909 and finished in May, 1910. The accomplishment of this work completed the detailed mapping of the northern portion of the Juneau gold belt, which contains all the important mines and most of the prospects under development. The Juneau and Berners Bay maps have already been issued, and the map of the intervening territory is now in course of preparation.

Detailed geologic examination of the region has succeeded the topographic mapping. Detailed reports are available on the geology and ore deposits of the Juneau and Berners Bay regions.[1] The present report, which is based on work done during parts of the field seasons of 1909 and 1910, aims to give in summary form the essential geologic features of the Eagle River region. A detailed report is now being prepared.

GENERAL GEOGRAPHY.

The gold belt consists of a narrow strip of country lying between the high peaks of the Coast Range and salt water. The general trend is northwest and southeast; the length of the belt as measured from Salmon Creek, which is 3 miles northwest of Juneau, to Berners Bay, on the north, is 32 miles; the width ranges between 4 and 5 miles.

The region is one of abrupt topographic features which increase in ruggedness toward the northeast. Here the numerous glaciers and precipitous relief make the mountains nearly inaccessible. The drainage of the region is mainly longitudinal, but the larger streams, like Eagle and Mendenhall rivers, which are of glacial origin, flow across the general trend of the belt.

[1] Spencer, A. C., The Juneau gold belt, Alaska: Bull. U. S. Geol. Survey No. 287, 1906. Knopf, Adolph Geology of the Berners Bay region, Alaska: Bull. U. S. Geol. Survey No. 446, 1911.

Gastineau Channel and Lynn Canal bound the region on the southwest, so that it is easily accessible by water, but owing to the facts that there are few good harbors and that the mountains rise directly from the coast, ingress to the interior of the belt is practicable at a few points only.

A well-built Government trail traverses the length of the belt and connects Amalga, on the head of Eagle River, with Juneau. This trail renders the extreme inland portion of the gold belt somewhat more accessible than it has been in the past, but for the transportation of heavy freight from Juneau the waterway is far more serviceable. The economical development of any mining property in the belt necessitates the building of a tramway to the nearest harbor, and this is the course that has been adopted at those places where any operations of importance have been undertaken.

GENERAL GEOLOGY.

The rocks of the region are arranged in belts striking parallel to the general trend of the gold belt. The dip is generally steep to the northeast.

Quartz diorite gneiss forms the northeast boundary of the belt. This rock, which in local speech is accurately enough known as granite, consists essentially of plagioclase feldspar (near labradorite), quartz, biotite, and hornblende, all of which are discriminable by the unaided eye. The gneissic structure, which is in part a primary structure but was produced mainly by the crushing of the component minerals of the diorite, toward the northeast grades into the massive granular texture characteristic of normal granitic rocks. Viewed broadly this gneissic belt, which is from 1 to 2 miles or more wide, forms the foliated margin of the quartz diorite core of the Coast Range.

A belt of schists adjoins the gneiss on the southwest. Its width ranges from 2 miles at Mendenhall Glacier to a few hundred feet at Berners Bay. The schists comprise a considerable variety of rocks, mainly of original sedimentary origin, and show a considerable diversity of mineralogic make-up. Biotite, garnet, and amphibole are the most common minerals of metamorphic origin that are easily distinguishable, and of these biotite is by far the most abundant and widespread. Coarsely crystalline white limestones are interstratified with the schists in small amount but are disproportionately conspicuous. Along the southeast side of Herbert Glacier a large volume of augite melaphyres is included in the schist belt. On glaciated surfaces the weather tinting shows that some of these rocks were originally conglomerates or breccias. The shapes of the fragments are well shown, and the fragments differ from one another in that some are more thickly studded with augite phenocrysts than others.

The schists are in many places exceedingly contorted. They are most highly crystalline where they adjoin the diorite gneiss, but toward the southwest they grade imperceptibly into the clay slates and graywackes of the next belt of rocks. In fact the boundary between the schists and the slate-graywacke formation was arbitrarily fixed by determining the first appearance of visible flakes of biotite in the rocks as the diorite gneiss is approached.

At many places along the contact of the schists ana gneiss the schists are extensively injected with dioritic dikes. The dikes possess a gneissic structure and lie parallel to the foliation and stratification of the schists; in places this interlayering is so thorough and the alterations induced so profound that it is impossible to tell what is diorite and what is schist.

South of Mendenhall Glacier the schists are intruded by numerous white granitic dikes of both coarse and fine grained varieties. Many of the dikes are contorted with the schists, but others cut across the folds.

The belt of slates and graywackes lying between the schists and the volcanic rocks (greenstones) paralleling the coast comprises the most important rocks in the region. Nearly all the ore deposits are located in it. This formation is typically displayed along the shores of Berners Bay and has been named the Berners formation.[1] Fossil leaves were found at that locality and indicate that the rocks are of Jurassic or Lower Cretaceous age.

The general strike of the rocks is northwest and southeast and the dip is almost invariably northeast, ranging from 20° to vertical. Angles of 40° to 60° are the most common. In places the rocks are acutely folded and the axes of the folds stand vertical, but no evidence of more extensive folding was procured. The cleavage in the rocks is generally parallel to their stratification, but discrepancies occur locally.

At Berners Bay the graywackes are intimately interstratified with the slates. Toward the south they become less abundant and are comparatively scarce south of Eagle River. At Auke Bay the graywackes are practically absent and the rocks consist of fissile black slates. The strata of graywacke, so far as observed, range to a maximum thickness of 80 feet.

The graywackes are gray or greenish-gray rocks of roughly schistose or massive structure. They are composed largely of grains of plagioclase feldspar and quartz, together with fragments of other minerals and rocks, embedded in an argillaceous cement. Except the glassy

[1] Bull. U. S. Geol. Survey No. 446, 1911, p. 17.

grains of quartz and the fragments of black slate, none of these constituents are recognizable by the eye. The fresh rock taken from mine openings is black, owing to the presence of finely disseminated carbonaceous material; that taken from the natural exposures is gray or mottled gray, because bleached by the action of the sunlight. The graywackes are far harder rocks than the soft slates interstratified with them.

With increase of argillaceous material in the graywackes the cleavage approaches in perfection that of the interbedded clay slates. Such rocks might be called graywacke slates. On cross-fractured surfaces some of them show only numerous glistening particles of quartz embedded in an aphanitic matrix.

Masses of volcanic rock form scattered areas throughout the belt of graywackes and slates. The most persistent development, however, is in the long belt fringing the coast from Point Bridget to Auke Bay. The volcanic rocks include lavas, flow breccias, tuffs and coarse breccias, and conglomerates. Clay slates are intercalated with them at some places, and it is a general rule that beds of fragmental igneous rocks alternate with normal sedimentary rocks near the margins of areas of dominantly volcanic rocks.

The characteristic feature of these rocks is the widespread prevalence in them of numerous well-formed and well-preserved augite phenocrysts set in a dark blue-green matrix of aphanitic texture. Feldspars are notably absent. Pending more complete petrographic investigation these rocks will be designated augite melaphyres, according to the descriptive field classification of Pirsson. In places they are extremely amygdaloidal; between Yankee Cove and Bridget Cove they display a striking ellipsoidal structure. The conglomerates consist essentially of volcanic material; the pebbles range from well rounded to angular; the matrix is tuffaceous or of volcanic origin, so that it is in many places impossible to discriminate conglomerates from breccias.

The bulk of the rocks show no schistose structure. The strike is northwest and southeast; the dip ranges from 20° N. at Auke Bay to vertical at Bridget Cove.

A considerable number and variety of dikes, mainly greenstones according to local usage of the term, are intrusive into the slates and graywackes, but with few exceptions all of them lie parallel to the stratification of the inclosing rocks. Dikelike masses of augite melaphyre, identical with the rock of the volcanic areas, are common, but whether they represent interbedded lava flows or intruded sills is determinable in few places. It is probable that both forms are present, but the distinction does not appear to be of practical importance. These sheets range from a few feet to 300 feet in thickness. They are hard massive rocks, but the contacts are, as a rule, thoroughly schistose.

Dikes of augite lamprophyre have a widespread distribution throughout the region, being found from Berners Bay on the north to Douglas Island on the south. They resemble the augite melaphyres in some respects but consist essentially of large augite phenocrysts embedded in a finely granular gray-greenish matrix. In some of these dikes augite crystals form the bulk of the rock; in the better-preserved specimens the augites are of fresh green vitreous appearance. Dikes up to 100 feet thick were noted.

Diorite porphyry dikes are found in the region south of Eagle River. Some of them, on account of their resistance to erosion, are unusually well exposed and form the beds of streams for several miles. These dikes are light-gray rocks consisting of white feldspar phenocrysts and scattered hornblende prisms set in a finely granular or dense groundmass. Some dikes of quartz diorite porphyry are found on the peninsula on the east side of Auke Bay.

A narrow belt of diorite 5 miles long extends south from Eagle River. This rock is of medium to fine grained granular texture and is composed of plagioclase feldspar, augite, and biotite. The feldspar is somewhat epidotized, and the rock tends to assume a green hue. This diorite differs considerably in appearance from the quartz diorite that occurs along the northeast margin of the gold belt, nor does it possess a gneissic structure. It probably represents a separate intrusion like the Jualin diorite at Berners Bay. A porphyritic diorite dike several hundred feet thick was traced for a distance of 7 miles southeastward from Eagle River along the hills flanking the east side of Peterson Creek. The rock carries numerous large tabular feldspars, which impart to it an individuality that distinguishes it from other dikes in the region.

ECONOMIC GEOLOGY.

The ore bodies are exclusively gold deposits. The great majority are stringer lodes; a few are fissure veins, and a number of mineralized dikes have been discovered.

Nearly all the ore bodies occur within the belt of slates and graywackes; a few are found in the quartz diorite gneiss; none of economic importance are known to occur in the belt of schists. The marginal portion of the slate-graywacke belt that adjoins the schists appears from present developments to be the longest zone of continuous mineralization in the district.

The ore bodies designated stringer lodes are belts of slaty or schistose rock cut by irregular quartz stringers. As a rule the ore bodies tend to follow the structure of the inclosing rocks, both in strike and in dip, but individual stringers commonly cut across the cleavage irregularly. Solid bodies of quartz are occasionally found and may apparently show the normal attributes of ordinary fissure veins, but such masses of quartz are invariably found to fray out into stringer lodes along both strike and dip.

Many of these ore bodies can hardly be said to possess definite walls. At some places, however, the better ore is found to occur in slate that rests upon a footwall of graywacke; at other places mineralization has taken place in slate lying along a footwall of augite melaphyre. In general terms, an intercalated sheet of harder and more massive rock is likely to serve as footwall. Where this is so the melaphyre, which is usually referred to as greenstone, is more likely to form a continuous wall than the graywacke, for the graywacke beds are inclined to have a short lenticular structure and to be discontinuous along strike and dip.

Except for sporadic shoots of rich ore, the stringer lodes are of low grade. They range in width from a few feet to 100 feet and apparently at a few prospects to 300 or 400 feet. The greatest depth attained anywhere in the district does not reach 200 feet. The average value of a stringer lode is dependent upon the number and richness of the individual quartz stringers contained in the whole mass of slate. As a rule the quartz veinlets are leanly mineralized with sulphides, and these have a tendency to be massed in and around fragments of slate inclosed in the vein stuff. Arsenopyrite is the commonest sulphide, and pyrite, galena, pyrrhotite, and sphalerite are found in the order named, but as a rule all do not occur together in the same deposit. Free gold is rarely seen. Auriferous arsenopyrite running several dollars to the pound is found near Echo Cove, and the association of arsenopyrite and galena is everywhere accompanied by high values in gold.

The fissure veins differ from the stringer lodes in consisting essentially of narrow tabular masses of quartz. Only a few representatives of this class are known—not more than five—and all of them have this feature in common, that they cut across the stratification and cleavage of the inclosing rocks. One or both walls are generally marked by fault planes.

The mineralized dikes are few in number and from present development appear to be of little economic interest, but in the writer's opinion they are entitled to a somewhat more careful examination by the prospector than has been accorded to them. They were noted on the northwest side of Mendenhall Glacier and between Lemon and Salmon creeks, where they are about 30 feet thick. The dikes are dioritic in composition and dark colored but where mineralized have been changed to a white rock, which is cut by numerous veinlets consisting of quartz, albite, and dolomite. The principal sulphide is pyrite; galena and arsenopyrite are present in minor amounts. Rutile occurs in sporadic large crystals of adamantine luster but more commonly forms acicular aggregates in which the individual needles lie at angles of 60° to one another. The smaller veinlets through the rock consist largely of albite, and where the structure is drusy this mineral is crystallized in typical feldspar forms. This highly interesting kind of mineralization is essentially similar to that which has affected the Treadwell dikes, a few miles to the south; unfortunately this mineralization was not everywhere accompanied by auriferous deposition of commercial value.

DEVELOPMENT.

The earliest operations in the region were those of placer miners on the heads of Montana and Windfall creeks in 1882. Old wing dams, ditches, and bowlder piles show where the pioneers labored, but because their efforts yielded a bare wage only, attempts at placer mining were soon abandoned. The first lode locations were made also in 1882 at Montana Basin and near Auke Lake. Prospecting has continued intermittently ever since. New discoveries are made from time to time and as late as 1908 extensive quartz croppings were uncovered near the point where the old trail crosses the summit between Auke Bay and Montana Creek. To those familiar with the region such discoveries occasion no surprise. Outcrops throughout the inland portion of the gold belt below timber line are effectually buried under several feet of glacial drift and this overburden is itself covered by a heavy growth of moss and vegetation. These features, together with the wet climate, render prospecting a difficult and onerous employment. It is therefore to be expected that occasional discoveries will continue to be made, aided as they have been in the past by the overturning and uprooting of trees and by the formation of landslides which from time to time bring to light new exposures of bedrock.

The state of development of the region in 1903 was described by Spencer[1] and in 1905 by Wright.[2] The development since that time has been far less rapid than was anticipated, and in view of the fact that a detailed report is in course of preparation, descriptions of individual properties are omitted in this preliminary account. Many causes have combined to retard the progress of the mining industry—litigation in some cases, inflated valuation in others—but principally the essentially low grade character of the ores. A large capital expenditure is necessary to open the properties, and such investments usually demand a more adequate development of the ore bodies than has so far been made in most places. Even at Juneau, where the ore bodies have had the advantage of being near a center of population, the formulation and adoption of plans for the working of the low-grade gold deposits on a scale proportionate

[1] Bull. U. S. Geol. Survey No. 287, 1906, pp. 117-134.
[2] Bull. U. S. Geol. Survey No. 284, 1906, pp. 34-37.

to their magnitude has required many years' time, and it is only recently that these plans have been nearing achievement.

The production of the region, with the exception of a few thousand dollars, has been the output of a single mine at Eagle River, which has been in operation since 1903.

PRACTICAL CONCLUSIONS.

The foregoing sketch of the geology presents only those features having a bearing upon the occurrence of the ores in this region. Some inferences of a practical character have already been pointed out. The most striking fact in the geology of the region is the almost complete restriction of the ore bodies to the belt of slates and graywackes. Although the ore bodies have been found distributed throughout the length and breadth of the area underlain by those rocks, they are nevertheless most numerous in the zone lying along the belt of schists. Moreover, the highest-grade ore yet found in the region and the only productive mine are in that zone. The conclusion is therefore obvious that those portions of the belt adjoining the schists that have not been adequately prospected are the most favorable fields for further investigation, notably the stretch between Windfall Basin and Eagle River, and possibly that between Mendenhall Glacier and Montana Basin.

In other parts of the slate-graywacke area the contacts with the intercalated masses of augite melaphyre, breccias, and conglomerates (rocks that are collectively known in the region as greenstone) appear to form favorable localities for mineralization. The masses of harder rock are apt to betray their presence, at least in parts of the region, by forming the bedrock of knobs or other topographic prominences.

A few small fissure veins have been found that break across the structure of the quartz diorite gneiss. The entire length of some of these veins is absolutely exposed on the bare glaciated surfaces and does not reach 200 feet; the width is a few inches. Although some of these veins contain considerable free gold, they nevertheless show a surprising lack of alteration of their wall rocks such as generally accompanies productive ore deposits. In view of this unfavorable feature and the short, narrow character of the veins, extensive sinking of shafts on them is a waste of time and energy. Where larger and longer ore bodies are indicated and the diorite is intensely altered by the action of vein-forming solutions, as on the flank of Mount Thane, further prospecting is to be encouraged.

The future of the district will, however, depend largely on the exploitation of the low-grade stringer lodes. The history of the mineral development of Silverbow Basin, at Juneau, will repeat itself here. In early days attempts were made to mine some of the stronger veins found in the stringered zones of slate in Silverbow Basin, but owing to the nonpersistent character of these veins such attempts assured a precarious existence to the mines founded on them. By a natural evolution that is still going on methods have gradually been developed to mine and mill the whole mass of rock of the ore-bearing zone, and the practice has now settled down to exploiting ores ranging from \$1.25 to \$3 a ton in value. This is likely to be the course of development in the northern extension of the Juneau gold belt.

THE UPPER SUSITNA AND CHISTOCHINA DISTRICTS.[1]

By Fred H. Moffit.

INTRODUCTION.

A topographic reconnaissance survey of that part of the south slope of the Alaska Range and the adjacent lowlands between the latitudes of Delta River and a point a few miles west of Mentasta Pass was made by T. G. Gerdine in 1902. At the same time the geology of this region, which includes the placer gold deposits of Chistochina River, was studied by Mendenhall.[2] This paper describes the continuation of that work in 1910. An account of the field work on which it is based is given on page 10.

The descriptions that follow deal principally with the two placer gold fields commonly known in the Copper River region by the names of their most important gold-producing creeks—Valdez Creek and Slate Creek. These two fields lie in the foothills on the south side of the Alaska Range. They are about 75 miles apart and are associated here because of their geographic position and the fact that they were visited in the course of the same summer's work rather than because of similarity or relationship between them. The two districts are represented in Plate VII (p. 114).

Valdez Creek is a tributary of Susitna River from the east and joins it a little more than 15 miles south of the nearest of the several glaciers from which the Susitna rises. Slate Creek, on the other hand, is a tributary of Chistochina River, which in turn is a northern branch of Copper River and is one of the three largest streams draining that part of the Alaska Range included within the Copper River basin. Both districts lie within the foothills of the Alaska Range, and their principal gold-producing streams are just above timber line—that is, between 2,500 and 3,000 feet above sea level. Fortunately, however, they are so near timber that the supply needed for fuel and for mining is procured with little difficulty.

[1] This paper is a preliminary statement of the results of a geologic reconnaissance by the writer and B. L. Johnson in the upper Susitna and Chistochina districts in 1910; it will be followed at a later date by a more extended account of the upper Susitna district.

[2] Mendenhall, W. C., Geology of the central Copper River region, Alaska: Prof. Paper U. S. Geol. Survey No. 41, 1905.

The nearest shipping point on the coast is the town of Valdez, which is about 130 miles almost directly south of a point midway between Valdez and Slate creeks. Since the discovery of gold in these two districts all supplies required by the miners have been brought in over the military trail from Valdez in winter. Freight for both districts passes over the same route from Valdez to Gulkana, but at that point the winter trails separate. Supplies for Valdez Creek are taken up Gulkana River and one of its western branches to a low divide leading to Maclaren River. Thence they are carried down the Maclaren to the Susitna and up the Susitna to Valdez Creek. These trails will be described in more detail in the account of Valdez Creek.

From Gulkana supplies for Slate Creek are taken up the Copper and the Chistochina to the camps at the head of the latter stream. These two winter trails will be better understood by referring to the map (Pl. VII).

The military trail, which for 12 years has been the route of entrance to the Copper River valley, has been turned into a road, and it was possible at the end of the summer (1910) to take wagons all the way through to Fairbanks from Valdez. This improvement is a great benefit to all the region in touch with the road, and the members of the Alaska Road Commission and those working with them deserve much credit for what they have accomplished. There still remains a great deal to be done in the matter of bridges and ditching, but those who have traveled over the old trail and the new road can not fail to appreciate the progress that has been made. A road also has been cut through from Willow Creek, between Tonsina and Copper Center on the military road, to connect with the Copper River & Northwestern Railway at the mouth of Chitina River, and when the bridge over Tonsina River is constructed communication between the coast and the upper Copper River valley will be far easier than it has been. This road will undoubtedly draw considerable traffic away from Valdez but will avoid the delays and difficulties that are presented by Thompson Pass in the winter and spring.

In the matter of mail communication with the outside, the Chistochina region is more fortunate than Valdez Creek. Gulkana is the last post office south of the Alaska Range on the military road out of Valdez, but a second mail route between Gulkana and Dempsey (near the mouth of Chisna River) by way of Chistochina was in operation in the summer of 1910 and a regular bimonthly service had been established. There was no mail service between Gulkana and Valdez Creek. The miners on Valdez Creek, however, received letters and a limited number of papers from Gulkana by an Indian messenger who was paid by private subscription. It would seem as if a summer service, which would benefit a greater number of people, could be established by carrying the mail from the coast to some point like Paxsons or Yosts on the Valdez-Fairbanks road, from which branch routes would connect with Slate Creek, 25 miles to the east, or with Valdez Creek, 65 miles to the west. Such an arrangement would make the most of the advantages offered by the military road, but these more northern branch trails, especially that to Valdez Creek, would hardly be practicable in winter, as both are above timber line and afford no wood for fuel.

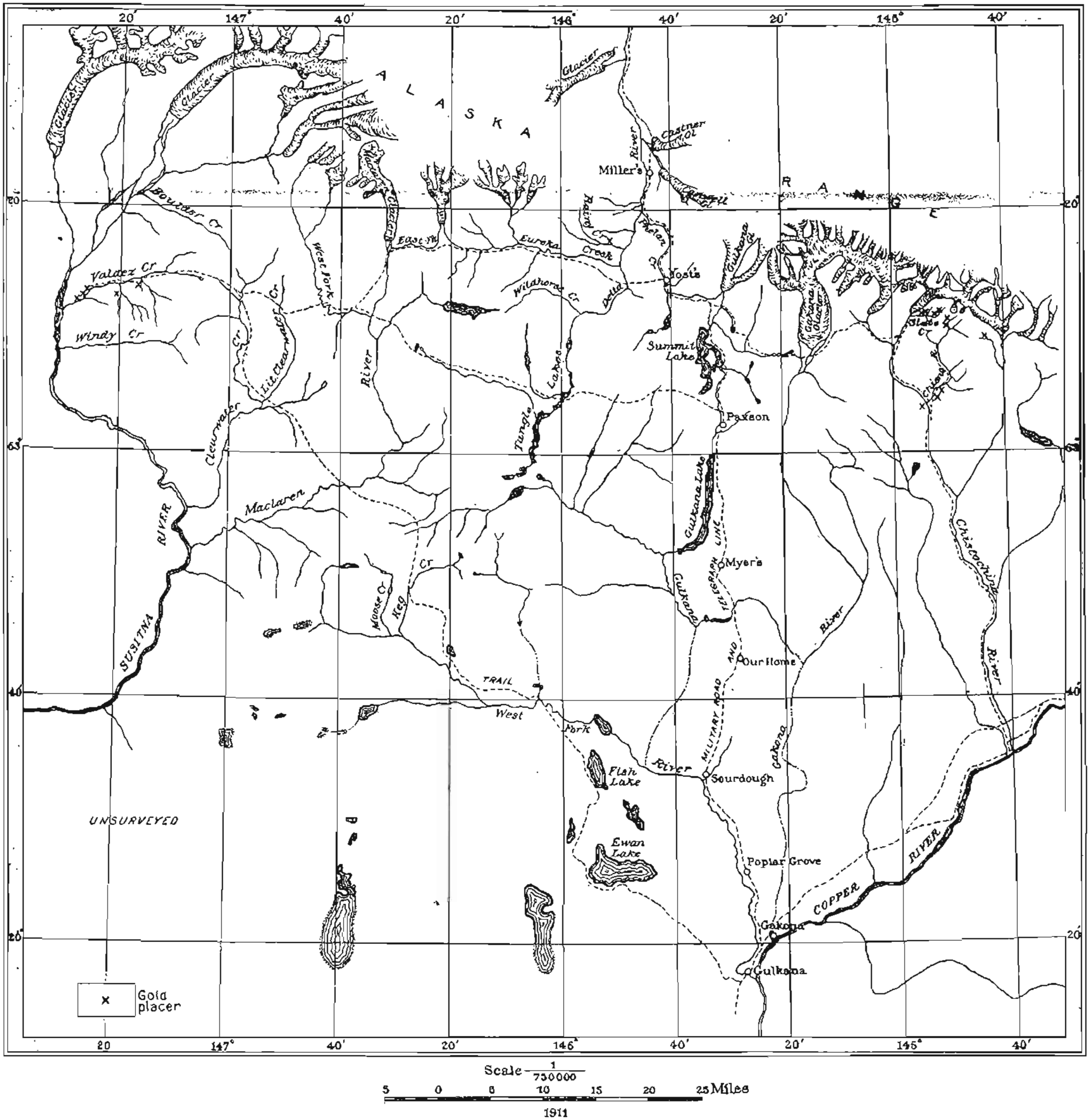
Although, with our present knowledge of the facts, it is too much to say that the gold occurrences of Slate Creek and Valdez Creek are exactly alike, there are, nevertheless, many points of similarity between them. The source of the gold in both localities is in slates that have been intruded by diorite and related granular rocks. It has not been shown that the slates of the two localities are of the same age, and in fact it appears more probable that they are not, but the intrusions of the slate by the diorite are believed to be approximately contemporaneous, whatever their geologic age may be.

No well-defined and persistent auriferous veins have yet been found in the slates, although small gold-bearing quartz stringers and lenses are present. Nearly all the streams heading in the Alaska Range between Slate Creek and Valdez Creek have shown the presence of gold in their gravels, but in most places the amount has not proved sufficient to make mining profitable. The one possible exception is Rainy Creek, a tributary of Delta River below Eureka Creek, on the west side. Five men were at work there in 1910 and in the early part of the summer had some promising prospects but were hardly making wages at that time. Prospecting on Delta River above Eureka Creek and on Little Clearwater Creek has not been successful, yet gold is present in the gravels. Although gold is widely distributed in this part of the Alaska Range, deposits of commercial importance are localized and few in number. It would seem that the best places for prospecting are in the slate areas, for there is no reason to believe that gold is present in the basaltic rocks and the diorite areas do not yield gold, notwithstanding the fact that the diorite intrusives were most probably connected with the origin of the gold.

VALDEZ CREEK.

GENERAL STATEMENT.

Valdez Creek has been a producer of placer gold since 1903, but it was not visited by any member of the United States Geological Survey previous to the summer of 1910. For that reason and because the published descriptions of the stream are few and incomplete, it is desirable to make the present paper somewhat more com-



SKETCH MAP OF UPPER SUSITNA AND CHISTOCHINA RIVER BASINS.

prehensive than would be necessary if the district had been fully described before.

Valdez Creek is approximately 14 miles long, but only a short stretch at its lower end yields placer gold at present (1910). Some of its tributaries, however, produce gold and others probably will do so in the near future. This creek, as previously stated, is a tributary of Susitna River. It rises in the mountain complex flanking the main Alaska Range and flows westward to the Susitna (Pl. VII). Its principal branch, Roosevelt Creek, heads in two small lakes that occupy the pass leading from Valdez Creek to Big Clearwater Creek and contributes nearly as much water to the main stream as does the upper part of Valdez Creek above the mouth of Roosevelt Creek. The two next largest feeders are Timberline and White creeks. Rusty Creek and Lucky Gulch are tributaries of White Creek and Roosevelt Creek, respectively. All these tributary streams are on the south side of Valdez Creek proper.

Valdez Creek flows through a strongly glaciated valley. South of it and around its headwaters are high, rugged mountains, but the mountains north of the lower or western end of the creek present smooth, rounded contours when viewed from the southern side, although the north slopes are precipitous. The valley is wider than most of the smaller stream valleys in the region to the east, especially at its lower end, where the valley of Valdez Creek joins that of Susitna River. This difference is pronounced, yet less so than that shown by the tributaries of Susitna River on the west side opposite Valdez Creek and to the northwest in the direction of Broad Pass. All the northern tributaries of Valdez Creek are comparatively unimportant, as regards both their present economic value as gold producers and the quantity of water they contribute to the main stream. They drain the smooth north slope of the valley and have cut deep gulches and canyonlike channels in its surface. The larger southern tributaries, on the other hand, occupy steep, strongly glaciated valleys and head in cirques that either contain the dwindling heads of old glaciers or were but recently vacated by them.

Valdez Creek has an abundant supply of water which is available for mines on the lower 4 miles of the stream and which can be secured with little difficulty and at small expense, considering the very high cost of supplies and equipment in this region. A rough measurement was made a short distance above the canyon for the purpose of obtaining data on which to base an estimate of the amount of water available for use below. This measurement, made at the end of August, showed from 3,000 to 5,000 miner's inches. These figures are, however, only a very rough approximation, and a long series of careful measurements should be made before installing any expensive plant to use this water.

TRAILS AND TRANSPORTATION.

The first miners on Valdez Creek came from Valdez by way of Valdez Glacier and the upper Klutina Valley. They crossed Klutina Lake on the ice, and after ascending St. Ann River to Hudson Lake they traveled north to the Susitna Lakes by way of Tazlina Lake, and then descended Tyone Creek to Susitna River, where they established a base camp and began their prospecting. During the first year or two of work on Valdez Creek supplies were brought from Valdez by this route, but it was then abandoned in favor of the better route by way of Gulkana, already described. All freighting is now done over the Gulkana trail. The smooth ice of Gulkana, Maclaren, and Susitna rivers gives a low-water grade for hauling that is practically continuous from Gulkana to Valdez Creek, for the divide between the Gulkana and Maclaren drainage, where crossed by the trail, is too low to be noticeable. The distance from Valdez to Gulkana is 128 miles and from Gulkana to Valdez Creek is approximately 125 miles. The cost of freighting from Valdez over this trail averages nearly 30 cents a pound (1910).

An attempt to establish a new winter route to the coast by way of Susitna River was not considered successful and has not been renewed. A few supplies, however, are brought in from Fairbanks each year by way of Nenana River and Broad Pass.

There is a choice of several routes for summer travel between Valdez Creek and the military road. The one usually followed is an old Indian trail from Bear Creek near the mouth of Gulkana River directly northwest to Valdez Creek, a distance of 105 miles. This trail is in timber all the way and has the disadvantage of being exceedingly wet in the open season. Another route, used only a few times, is from Paxsons to the west fork of Maclaren River and thence to Valdez Creek by way of the Roosevelt Lakes. This trail is about 65 miles long, but it is above timber line after it leaves Paxsons except in the vicinity of the Tangle Lakes and has another disadvantage in that it crosses a number of ridges, ranging in height from 500 to 1,000 feet above the valleys. The shortest and easiest trail is from Yosts, or some near-by point on the military trail, to Maclaren River by way of Eureka Creek, and thence to Valdez Creek by way of the Roosevelt Lakes. This trail is above timber except at Delta River. The only ridges of consequence which it crosses are between the forks of Maclaren River and between Maclaren River and Little Clearwater Creek, both of which can be avoided by a little labor in brushing out a trail. This northern trail, however, is very little shorter than that from Paxsons.

GENERAL GEOLOGY.

The statements that follow regarding the geology of Valdez Creek apply to the immediate vicinity of the creek (see fig. 15), yet the same geologic formations are widely distributed in the region both to the east and west.

Slate forms the bedrock of Valdez Creek throughout its length except for a short distance at the upper or east end. Locally the slate has been changed into schist. This change was brought about

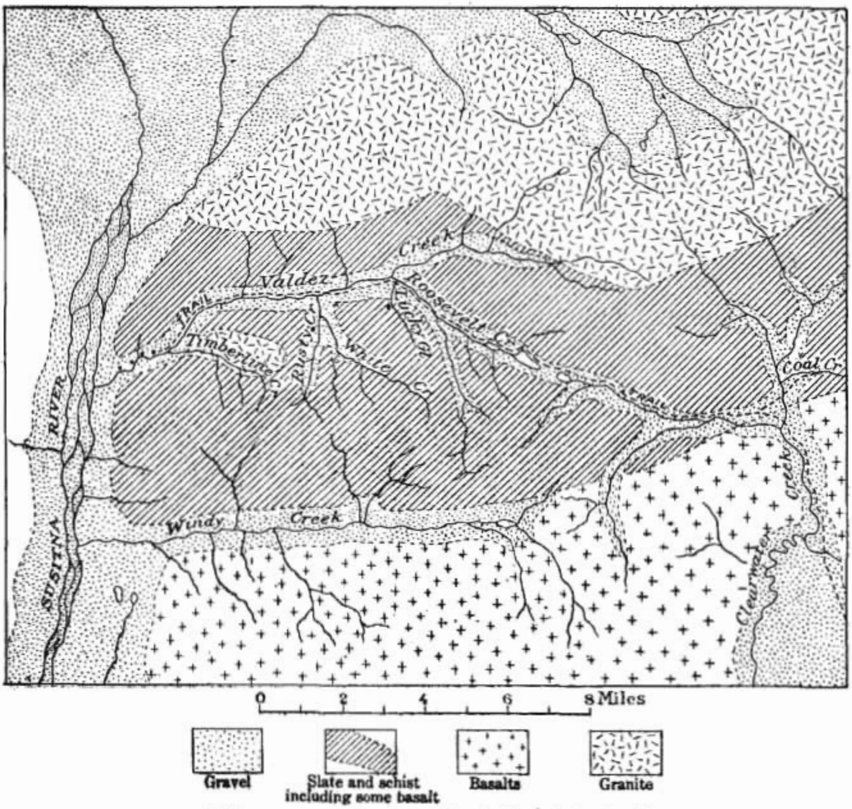


FIGURE 15.—Geologic sketch map of the vicinity of Valdez Creek.

by the intrusion of granite and related light-colored granitic and porphyritic rocks into the slates and by moderate folding, which probably took place during and after the time of granite intrusion. The slates are associated with limestone and shale beds that contain Upper Triassic fossils, but convincing evidence of their Mesozoic age is still lacking.

South of the slate area is a belt of dark basaltic rocks whose stratigraphic relation to the slates has not yet been determined beyond question. The basalts have a bedded appearance and have undergone deformation that is shown by folding. They are best developed on Windy Creek.

The slate area is bounded on the north by diorite, which is exposed over a large area that includes the head of Valdez Creek and most of the ridge north of it. The diorite intrusions are younger than the slates but may possibly differ much in age among themselves, since there is a wide variation in the amount of metamorphism that has taken place in them. At the head of Valdez Creek part of the diorite appears to be fairly fresh and little altered, but in the ridge north of Valdez Creek the changes are great. The rock has a gneissoid structure and a pronounced cleavage, whose production was accompanied by the formation of such minerals as cyanite and garnet in the adjacent schistose sediments. Great alteration has taken place in the sedimentary rocks adjacent to the granite intrusions north of Valdez Creek, and the schistose character is highly developed there. Schistosity decreases as distance from the granite intrusion increases till it practically disappears in the slates south of Valdez Creek, although the regularity of the decrease is affected in some degree by smaller intrusive masses such as that on Timberline Creek.

The principal rock formations of the Valdez Creek vicinity, then, are the dark basaltic rocks of Windy Creek, the slates and schists into which the slates that occupy most of the Valdez Creek valley have been changed, and the granite that was intruded into the slates and is most widely exposed north of Valdez Creek.

The unconsolidated deposits of Valdez Creek consist chiefly of talus material that mantles the mountain slopes and the gravels that cover the valley floor. The gravel deposits include, of course, the present stream wash, but they are made up chiefly of bench deposits and are intimately associated in their origin with the glaciation of the valley. The rock fragments are chiefly slate and schist, with much associated igneous material. The gravels contain an uncommon proportion of large granite bowlders. During the period of maximum glaciation Valdez Creek valley and the adjacent Susitna Valley were filled with ice, but the Susitna ice stream was able to contribute to the gravels of lower Valdez Creek some rock foreign to the valley. A very important feature of Valdez Creek, in connection with the distribution of its gravel deposits, is the fact that the present stream channel is not the original channel. Before the present canyon was developed the creek had cut an earlier but shallower canyon in bedrock. This was overridden by ice from the north and east and filled with gravel, and when at last the ice disappeared and the creek established a new channel for itself, its new course did not coincide with its old one. The present canyon is cut into the slates 60 feet deeper than the old canyon at the place of their intersection on claim "No. 2

above" and is now 170 feet below the top of the benches on either side of the creek at that locality.

ECONOMIC GEOLOGY.

The placer gold of Valdez Creek has its chief source in the slate area south of the creek. This is fully proved by the results of prospecting on the tributary streams. The tributaries that flow into the main stream from the north have been found to carry only a small quantity of gold, not enough to encourage prospecting. On the other hand, all the gulches and creeks that cut the slates to the south carry gold, and in many places even the loose slide rock on the slopes yields a good string of colors on panning.

Among these southern tributaries Lucky Gulch has been a gold producer for several years and Rusty and White creeks give promise for the near future. There appears to be little doubt that the hill between Valdez Creek and White Creek extending east to Roosevelt Creek is one of the principal areas of mineralization, although it is not the only one. The slates are cut by light-colored igneous intrusives and by small quartz veins. Many of these quartz veins carry gold in sufficient quantity to encourage careful examination, yet little attention has been given to prospecting for lode deposits of gold in the district.

The total production of the Valdez Creek district is about $260,000. Mining operations in this district in 1910 were restricted to a few creek claims on Valdez Creek, to the Monahan tunnel, Lucky Gulch, and Rusty Creek. Assessment work was done on many other claims, but this was only to hold the property for future development.

The creek claims on Valdez Creek that have received most attention are "Discovery claim," "No. 1 below," "No. 2 below," "No. 2 above," and "No. 3 above." (See fig. 16.) "No. 1 above" includes a deep rock-walled canyon too narrow to permit mining. The richest of the productive claims were "Discovery claim," "No. 1 below," and the lower half of "No. 2 above." There is little variation in the character of the gravel on the creek claims. It ranges from 3 to 8 feet in thickness and consists of slate, schist, and granite, together with a small proportion of light-colored porphyritic intrusives and dark basaltic and tuffaceous material. An important characteristic of the gravel deposits is the great proportion of large granite bowlders. Such bowlders are difficult to handle in the cuts and add much to the cost of mining. Many of the larger ones are too heavy to lift with the ordinary means at hand and are moved only by undermining them on one side and causing them to roll over.

The gold in the creek claims shows considerable variation in its appearance. Part of it is flat and smooth, but another part is rough and little worn. Gold from the claims above the Monahan tunnel shows less wear than that below. A large amount of "ruby sand" or garnet is associated with the gold, yet less "black sand" is present than might be expected from the quantity of igneous material contained in the gravel. A little more than one-third of the total gold production of Valdez Creek from 1903 to 1910 has come from these creek claims, but it is expected that their yield will be considerably less from now on, because so far as known most of their richest gravel has been mined out.

The Monahan tunnel is of particular interest, both geologically and because it has yielded more gold than any other single property in the district and nearly as much as all the others together. This tunnel follows the bottom of an old filled-in canyon in the slates, which

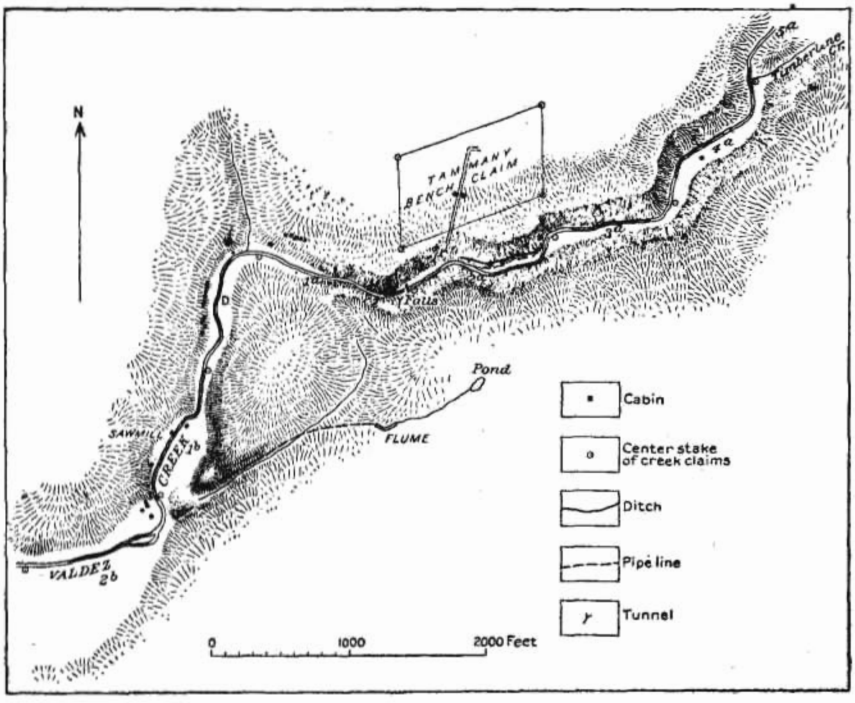


FIGURE 16.—Sketch map of part of Valdez Creek, showing placer-mining camps. D, Discovery claim 1a, claim "No. 1 above," etc.

makes an angle of about 45° with the present course of Valdez Creek at their point of intersection. It starts on claim "No. 2 above" at an elevation of approximately 60 feet above the present creek bed and is driven across the north half of the creek claim into the adjoining Tammany bench claim. (See figs. 16 and 17.) Its position south of Valdez Creek has not been determined. Its present length is about 700 feet. The course of Valdez Creek at the tunnel's mouth is east-northeast; that of the tunnel itself is north-northeast. The distance from the tunnel floor to the surface of the bench above is 110 feet, which represents the depth of gravel filling in the old canyon, for on either side of the tunnel slate bedrock is seen outcropping within a few feet of the surface of the bench. The canyon is not straight, yet the variations in its course so far discovered are not important, unless the last abrupt turn to the east near the end of the present workings marks the beginning of a new course.

Bedrock in the tunnel is slate or schist. It is not fractured enough to permit gold to penetrate it far. Crosscuts from the tunnel, one about 100 feet to the west and one 60 feet east, show that the bedrock rises steeply on either side and that the walls are waterworn. The measurements in these crosscuts, however, do not indicate the general width of the canyon, for the tunnel in most places is at or near the canyon wall and the measurement of 100 feet is probably a maximum. In many places the width is much less than that.

There is no difference between the kind of rock material making up the gravel in the old canyon and that in the creek, but there are variations in its character. The lower 50 feet of gravel in the canyon contains flat granite bowlders with rounded edges, rounded slate and schist fragments, and fine black clay. Above this the canyon filling shows more of the large granite bowlders, but they are round rather than flat, the gravel is not so clean as below, and the whole deposit has an appearance of greater disorder.

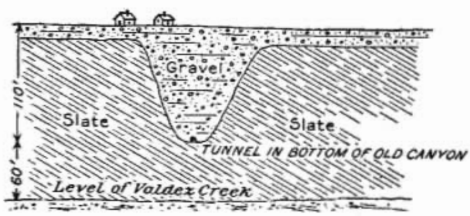


FIGURE 17.—Diagrammatic section showing relation of the Monahan tunnel to Valdez Creek. The old canyon intersects the present channel at an angle of 45° and is 60 feet above it.

Gold is found chiefly in the lower 5 feet of gravel, although there is fine gold in the upper part also. Most of it is contained in the hard black clay and fine rounded slate gravel. The gold is coarse, flattened, and smooth for the most part, yet a few rough nuggets, some of them containing quartz, are present. Although heavier, it much resembles the gold of the creek claims below.

If it should become desirable to apply hydraulic methods in the mining of these bench gravels, the favorable conditions for obtaining a good water supply and a dump for tailings are to be noted.

Aside from the Monahan tunnel, mining operations were conducted in the bench gravels of this creek at one other locality. A small tributary joins Valdez Creek at the upper end of claim "No. 2 below." It drains a slight depression southeast of the main creek and at its upper end is probably not over 175 feet above the creek. At its lower end it drops over the high rock wall of the main stream, where an excellent dump for tailings is thus provided. Water was brought from Timberline Creek, a distance of 1½ miles, by a ditch and a short line of pipe for the purpose of moving gravel on the bench at the mouth of the little stream, and mining operations were carried on in 1909 but were not continued in 1910. The gravel resembles that of the creek except that it is cleaner and contains more sand. The same trouble from bowlders was experienced here as on all other parts of Valdez Creek.

Lucky Gulch is a small gulch tributary to Roosevelt Creek near the junction of Roosevelt and Valdez creeks and is about 6 miles from the main camp on Valdez Creek. It is a steep, narrow gulch, little more than a mile long, and draws most of its water from melting snow. Since the gulch is on the north slope of the mountain, the snow that drifts in and fills it in winter melts slowly in summer, thus both preventing work in the early part of the open season and providing the only source of water for mining later in the summer. The slate bedrock of Lucky Gulch dips about 20° N., so that the dip of the slate and the fall of the creek are about the same in many paces. On account of the narrowness and steepness of the channel there is no opportunity for the accumulation of any considerable body of gravel, and such as does accumulate consists of angular fragments and slabs of slate. Well washed and rounded gravel is present only in small amount.

The gold from Lucky Gulch is coarser than that from any other part of the Valdez Creek district. In general it is rough, with spines and protuberances, yet some of the large pieces are flattened and smooth. Large nuggets form a very considerable part of the product of the creek. One was found in 1910 that weighed 32 ounces. The largest ever found weighed 52 ounces. Many of the nuggets contain sugary quartz, and it is evident that the gold is of local origin and has traveled only a short distance.

A short season and small supply of water counterbalance in large measure the advantage due to the freedom from granite bowlders that Lucky Gulch enjoys over Valdez Creek. Large slabs of slate are common in the gulch, but most of these can be broken with a sledge, or, if this fails, with a small charge of powder, and thus removed. The gravel deposits are worked by booming or sometimes with a small nozzle and hydraulic hose. Part of the gulch has been worked out, but there still remains a large amount of ground to be exploited.

Rusty Creek is 4½ miles east of the Valdez Creek camp and is the principal tributary of White Creek. The valleys of these two streams, White and Rusty creeks, are the largest that have been cut into the mineralized slate mass south of Valdez Creek. They head in the complex of slates, tuffs, and basalts of the ridge north of Windy Creek, and run north through the slates to Valdez Creek. Both of these streams offer promising ground to the prospector. Such prospecting as has been done on White Creek has not resulted in any definite results and was carried on under much difficulty and expense, due in part to the high cost of supplies and lumber but principally to troubles that arose from depth of gravel and much water. Such results as were obtained did not appear to the miners to warrant the heavy expense required for thorough prospecting at that time.

Prospecting on Rusty Creek has been conducted for three years in the face of many difficulties and much expense without any returns, and it was not till the end of the 1910 season that results of much promise were obtained. During the three years preceding, a large cut several hundred feet long and over 25 feet deep in places was made in the creek channel just at the place where the White and Rusty Creek valleys join Valdez Creek valley. This was accomplished by booming—that is, by the use of a dam with an automatic gate which opens periodically and releases a large volume of water. The water rushes through the cut, tearing up the gravel and washing it away. By this method a deep, narrow cut, begun in the expectation of reaching bedrock at no considerable depth, was made in the gravel deposits. The cut follows the east wall of an old gulch or canyon and exposes the northward-dipping slates on that side, but the bottom of the canyon was not reached at the end of the working season of 1910.

The gravels filling the old gulch include an upper deposit of unsorted glacial débris from 10 to 20 feet thick, made up of slate and basalt. Below this is another deposit of fairly well sorted gravel and coarse sand with a distinct cross-bedding. There are many large bowlders in the cut, derived chiefly from the upper glacial deposit. Most of them are basaltic in character and come from the head of Rusty Creek. There are also a few granite bowlders.

Encouraging gold prospects have been secured from the projections or benches of the rock wall on the east side of the cut and especially from the bottom of the cut, where work ended in 1910. The gold is very rough and bright. Few pieces of greater value than 20 cents were found during any of the mining until the end of last season, but there was a noticeable increase in coarseness in the last gold taken out that lends encouragement to the belief that the bottom of the cut is now near bedrock.

Rusty Creek and White Creek give greater promise for extension of the gold-producing ground of the district than any of the other streams, and it is believed that they should be thoroughly prospected. It is impossible to predict whether the concentration of gold in their gravels will be found sufficient to yield rich placer deposits, but the streams cut mineralized slates that are known to be gold bearing and there has undoubtedly been some concentration of gold during the time that erosion of the slates has gone on.

Timberline Creek also is another possible source of placer gold, as it heads in the mineralized slate area. A little prospecting has been carried on, but without particularly encouraging results. The discovery of other gold-producing gravels in the Valdez Creek district is highly desirable, because it is evident that most of the rich channel gravel of the original creek claims is worked out.

CHISTOCHINA GOLD FIELD.

All the gold-producing ground of the Chistochina district lies between the west and middle forks of Chistochina River. It includes Slate Creek and Miller Gulch, Chisna River, its tributary Ruby Creek, and the tributary of the Middle Fork called Lake Creek on the older maps but now known to the miners as Lime Creek. To complete the list of localities where mining operations are conducted in this district, there should be added that on the west side of Chistochina River, near the mouth of Chisna River, where the post office, Dempsey, is situated.

The geology of this small area was described by Mendenhall[1] and may be stated briefly as follows: South of the depression formed by the valleys of Slate Creek and the upper part of Chisna River is a series of tuffs, quartzites, and conglomerates with associated igneous rock, called the Chisna formation. This formation is conspicuous because of its red color, due to the oxidation of pyrite in the rocks that form it. North of the depression is the Mankomen formation, which in this vicinity is made up of limestone and shale, locally metamorphosed to slate. These two formations are separated by a fault of unknown displacement by which the Chisna formation is raised relatively to the Mankomen. The Mankomen formation is of late Carboniferous age. The Chisna formation is older, but probably Carboniferous also. Patches of coal-bearing Tertiary shale have been exposed in the channel of Slate Creek by mining operations.

During the last 11 years, since the discovery of gold in 1899, most of the rich creek gravels of Slate Creek and Miller Gulch have been worked out, yet there still remain creek claims of lower grade and bench gravels that have not been touched. The total production of Slate Creek and Miller Gulch is about $1,500,000.

There are about 20 creek claims on the channel of Slate Creek and 7 on Miller Gulch. Between 40 and 50 men were employed in the Chistochina district in 1910, most of whom were on Slate Creek. They were scattered along at several camps, from "No. 3 below" to the lower end of the creek.

[1] Mendenhall, W. C., Geology of the central Copper River district: Prof. Paper U. S. Geol. Survey No. 41, 1905, pp. 24 et seq.

The first three claims above the mouth of Slate Creek are virgin ground but are difficult to work because of the depth of the gravel and the large amount of water. A hole 21 feet deep near the south side of the gravel bar did not reach bedrock. Tailings from the claims above are another source of trouble. A dam was built on the lowest claim in 1910 to furnish water for *booming* a low bench on the north side of the creek. This was not completed in July, 1910, when the creek was visited.

On the fourth, eighth, and ninth claims above the mouth of Slate Creek mining was confined to the bank on the south side of the stream. A heavy deposit of glacial material, consisting of blue clay or glacier mud and large bowlders, is exposed on that side. It is overlain by a deposit of frozen yellow talus material or shale rock from the mountain side on the south, ranging from 5 to 25 feet in thickness. The glacial material contains gold and is exploited by undermining and caving. Bowlders are piled back from the cut to form a channel along the foot of the bank and then the water is turned in to cut the bank, and wash away the fine gravel. Afterward the remaining gravel and gold is shoveled into the sluice boxes. This work is slow and very dangerous, because the high bank of frozen gravel above sloughs off continually as it thaws and at times breaks down in large masses, so that men must be constantly on the alert and ready to jump to a place of safety.

The largest force of men on the creek was at work near the mouth of Miller Gulch on ground that has been the richest of the district and is still producing gold. This Tacoma claim, as it is called, together with the lower part of Miller Gulch, has yielded much more gold than all the other claims together. The gravels of Slate Creek above Miller Gulch are of lower grade than those below, and fewer men have been employed there, yet their contribution to the gold production of the creek is important.

There was less mining on Miller Gulch in 1910 than in previous years. This was not due to the exhaustion of gold-bearing gravels. Work was partly suspended in order to avoid covering unworked gravels in Slate Creek with tailings and will be resumed another year. The water supply of Miller Gulch available for mining operations is small, so that it has been the custom of the two principal claim owners to use it in alternate years. In this way all the bed of the gulch has been worked out, but there still remain bench gravels that will be exploited as soon as the ground below can be used for dumping.

The most important gold-producing creek in this district, after Slate Creek and Miller Gulch, is Ruby Creek, which lies just east of Slate Creek across a low, flat divide. Ruby Creek has thrown out a broad fan of gravel extending outward in a semicircle from the point where the creek leaves the narrow gulch in the mountains at the head of Chisna River, thus forming a smooth slope to the west, south, and east. The creek has cut a channel ranging from 15 to 20 feet in depth in this gravel fan. The gravels are gold bearing and mining is carried on in them, and also in a short bend of filled and abandoned channel at the head of the fan just within the gulch. From some cause the creek cut a new rock-walled channel within a few feet of its former channel at the point where it leaves the mountain. The gold content of the gravels that filled the old channel is low but still great enough to encourage prospecting and pay the bare expense of doing it. Work is greatly hindered by snow and ice, which in some summers do not melt, so that even the water for sluicing is brought through a tunnel in the ice. Bedrock has not been exposed in the channel of Ruby Creek where it crosses the gravel fan. The false bedrock which holds the gold is a gravelly clay bed but a few inches in thickness. Ruby Creek, in cutting its present channel, has concentrated the gold contained in the gravel removed and has left it on these clay beds. Only a few feet of gravel is shoveled into the sluice boxes and care is used not to go below the false bedrock into the barren gravel beneath.

Mining operations on Lime Creek at the head of the middle fork of Chistochina River are on a bench well above the creek and about 1½ or 2 miles east of the divide between the heads of Lime Creek and Chisna River. The section exposed in mining shows about 6 feet of heavy bowlder wash resting on blue glacier clay containing small angular fragments, which is overlain in turn by more of the heavy bowlder wash, the whole section having a thickness of 30 to 40 feet. A large amount of greenstone is present in the deposit and is associated with slate, limestone, conglomerate, and granite. The richest deposit of gold is found in a rusty gravel seam on the blue-clay bedrock. Copper nuggets ranging in size from shot to pieces of several pounds are caught in the sluice boxes. They resemble those of Chititu and Dan creeks, in the Nizina district, and like them are probably derived from copper deposits in basalts or greenstones. Greenstone that resembles the Nikolai greenstone[1] is exposed in the mountain northwest of Lime Creek.

Work on Chisna River was in the nature of assessment work and prospecting. Considerable ground is held there by different persons awaiting the time when the introduction of hydraulic machinery or other economical mining methods shall make mining more profitable. At present the cost of labor and supplies prevents development of much of the gold-bearing gravels. Wages are $10 a day without board, and freight costs from 20 to 25 cents a pound.

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[1] Schrader, F. C., and Spencer, A. C., The geology and mineral resources of a portion of the Copper River district, Alaska, a special publication of the U. S. Geol. Survey, 1901, p. 40. Moffit, F. H., and Maddren, A. G., Mineral resources of the Kotsina-Chitina region, Alaska: Bull. U. S. Geol. Survey No. 374, 1909, p. 23.

Work at Dempsey is also in the nature of prospecting. Considerable time has been expended in driving a tunnel into the bench gravels west of Chistochina River in the belief that an old channel would be discovered. The gravels yield some fine gold.

Mendenhall regarded the slates of the Mankomen formation as the source from which the placer gold was derived. This conclusion appears justified by the distribution of gold in the gravels, the character of the gold itself, and a study of the geology of the region. It seems evident, for instance, that the richness of Miller Gulch was due to local mineralization of the slates and concentration of gold in the gravels formed during erosion and weathering of the rocks containing it. Failure to find important lode deposits can not be considered as evidence against this source of the gold any more than the failure to find large nuggets in a gravel deposit is evidence that no gold is present. The presence of bowlders of granite, hornblende porphyry, and other rocks from the main range north of Slate Creek is one of the results of former glacial activity but is not in itself proof that the gold of Slate Creek was introduced in the same way.

If the principal source of gold in this district is in the Mankomen formation and the gold of Chisna River is derived from that source, as is indicated by the fact that so far as the writer knows these streams cutting the Chisna formation are not gold bearing except where they have received some contribution of foreign gravels from the north, it is probable that rich pay streaks with coarse gold should not be expected on the lower Chisna and Chistochina. The hope of prospectors there should be for the discovery of large supplies of low-grade gravels that may be exploited in an extensive way by economical means. This statement is believed to be valid unless it shall be shown that there is some other source of the gold than that referred to previously.

PRELIMINARY REPORT ON A DETAILED SURVEY OF PART OF THE MATANUSKA COAL FIELDS.

By G. C. Martin.

INTRODUCTION.

The purpose of this paper is to present briefly the more important practical results of a detailed geologic investigation of the area covered by the Chickaloon special map. This area includes the commercially more important part of the Matanuska coal fields, which is situated in the south-central part of Alaska about 30 miles northeast of the head of Cook Inlet.

The larger geographic and geologic features of the Matanuska Valley are described and all the information then available concerning the coal is given in earlier publications,[1] to which the reader is referred. The contents of this paper are but the summary of and the provisional conclusions from the results of the detailed investigations of 1910, which will subsequently be published in full.

GEOLOGIC OUTLINE.

GENERAL FEATURES.

Among the more important geologic results of this investigation is the acquisition of a considerable amount of new information concerning the local stratigraphic sequence. These facts will be presented in detail in the final report. The following table gives a summary of the geologic succession of the rocks in accordance with the new information:

[1] Martin, G. C., A reconnaissance of the Matanuska coal field, Alaska, in 1905: Bull. U. S. Geol. Survey No. 289, 1906, 36 pp. Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: Bull. U. S. Geol. Survey No. 327, 1907, 71 pp.

General sequence of rocks in area covered by Chickaloon special map.

Age.	Character of rocks.	Thickness.
Quaternary.	Alluvium, terrace gravels, and moraine.	*Feet.* 0–300+
Pliocene (?).	Lavas, capping Castle Mountain.	800
	Intrusive rocks, mostly basic.	
Miocene (?).	Conglomerate, on Castle Mountain and Wishbone Hill.	3,000
Eocene.	Shale and sandstone, with coal beds.	2,000±
	Arkose, conglomerate, and shale, without known coal.	2,000±
Upper Cretaceous.	Sandstone and shale.	4,500±
Lower Cretaceous (?).	Limestone.	200±
Lower Jurassic.	Volcanic breccias, agglomerates, and tuffs.	1,000±
Early Mesozoic or older.	Granitic rocks.	
Paleozoic.	Gneissic rocks.	

CRYSTALLINE ROCKS BENEATH THE COAL.

The rocks grouped under this heading in this discussion and on the geologic map (Pl. VIII) include the gneissic and granitic rocks, the Lower Jurassic volcanic breccias, agglomerates, and tuffs, and the possibly Lower Cretaceous limestone represented in the general section above. These rocks are grouped together because of the facts that they are all known to be far beneath the coal and that none of them are individually of importance in a discussion of the coal.

Large bodies of gneissic and granitic rocks, which are intimately associated with one another and which have not been separated, occur in the Talkeetna Mountains and are present along most of the northern border of the area represented on the map.

Lower Jurassic volcanic breccias, agglomerates, and tuffs occupy an area east of Kings River along the northern edge of the area shown on the map, and are probably present also in the valley of Coal Creek. These rocks are overlain by a presumably Lower Cretaceous limestone which has been seen only along the northern border of the mapped area east of Kings River.

MESOZOIC SEDIMENTARY ROCKS.

The rocks included under this heading comprise the Upper Cretaceous shales and sandstones of the table on page 129. They apparently have a thickness of at least 4,500 feet. These beds lie beneath the coal-bearing rocks, and consequently the area occupied by them is barren of coal. It should be noted that the character and age of these beds were not recognized in the earlier investigations and that they are included in the areas mapped as Tertiary by Martin[1] and by Paige and Knopf.[2]

TERTIARY ROCKS.

The Tertiary rocks of the Matanuska Valley have been divided into three sedimentary formations and include also volcanic and intrusive rocks.

ARKOSE, CONGLOMERATE, AND SHALE, WITHOUT KNOWN COAL.

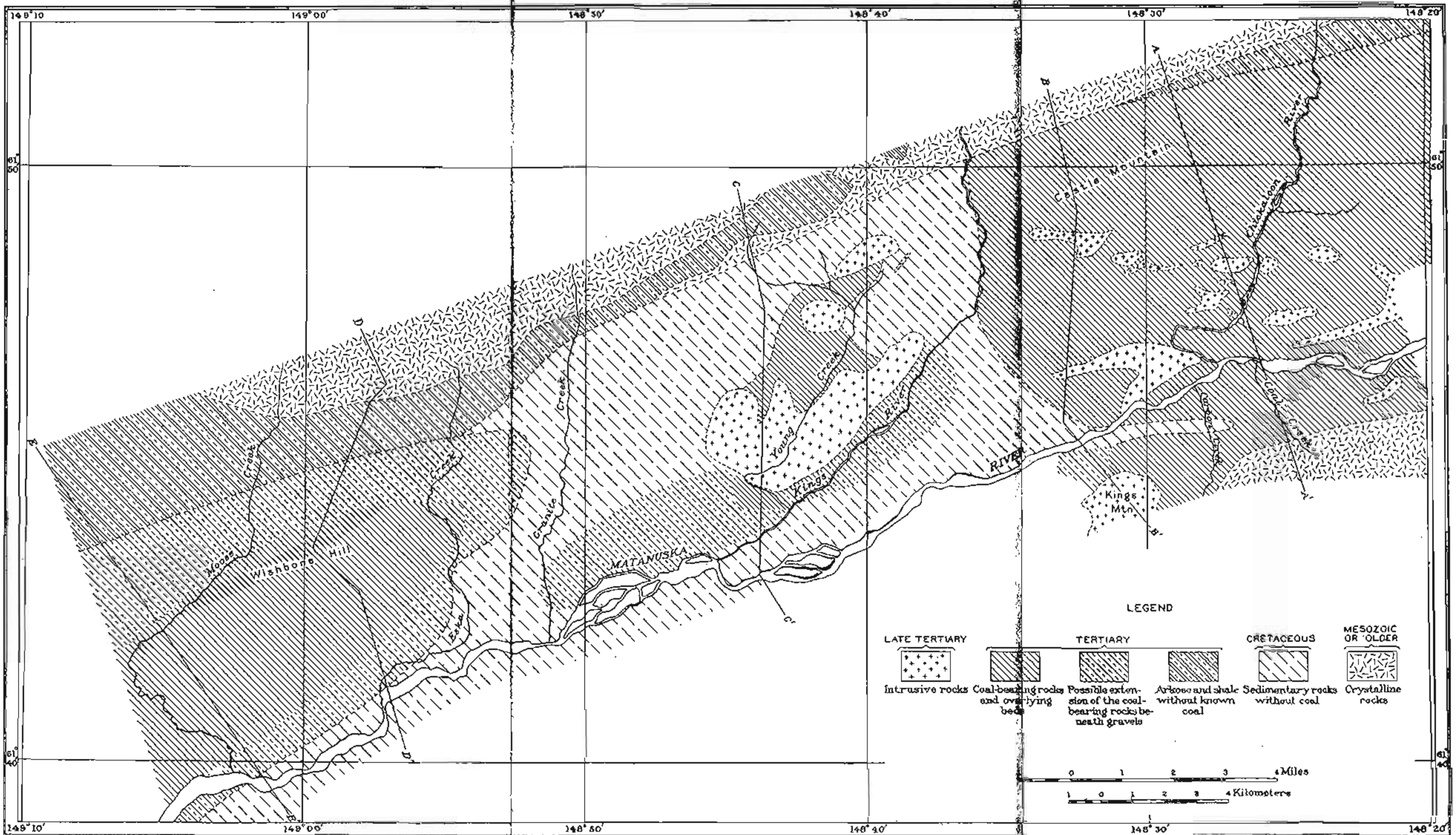
The basal division of the Tertiary consists of beds predominantly arkosic and well indurated, which occupy large areas along the northern border of the Matanuska Valley. These rocks are apparently without coal. They have been separated from the other Tertiary sedimentary beds described below on the basis of their predominantly arkosic character, greater degree of induration, and absence of coal. There is believed to be little doubt that these rocks are for the most part low in the local Tertiary sequence and include the basal beds, although there is a possibility that the assemblage represented on the map includes in part the marginal facies of some beds higher in the Tertiary, as well as higher beds not necessarily marginal but now occurring in structural zones in which they have been deformed to a degree not permitting their separation from the basal or marginal deposits. The thickness of these beds exceeds 2,000 feet.

COAL-BEARING ROCKS.

The coal beds of this district occur in a rather monotonous succession of shales and sandstones. The shales, which predominate over the sandstones in aggregate thickness, are gray to drab, rather soft and inclined to disintegrate on exposure, poorly bedded, and without well-defined joint planes. Most of the beds are rather gritty and vary in grain along the bedding. They contain many nodules and lines of nodules of iron carbonate, some of which form fairly persistent beds. The sandstones are yellowish, rather soft, of diverse grain in the different beds and of varying grain in the same bed, for the

[1] Martin, G. C., Geologic reconnaissance map of the Matanuska Valley: Bull. U. S. Geol. Survey No. 289, 1906, Pl. III.

[2] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance map of the Matanuska and Talkeetna region: Bull. U. S. Geol. Survey No. 327, 1907, Pl. II.



PRELIMINARY GEOLOGIC MAP OF PART OF THE MATANUSKA COAL FIELD.

most part feldspathic, and in general the individual beds are not very persistent. The thickness of the coal-bearing rocks is doubtful, but it appears to be at least 2,000 feet.

Fossil leaves are present in both shales and sandstones and are especially abundant and well preserved in the beds carrying iron carbonate.

The coal beds are numerous. There is no evidence as to their exact position within the formation or as to the persistence of individual beds or groups of beds.

The coal-bearing beds are overlain by conglomerates aggregating about 3,000 feet in thickness. These conglomerates are well exposed in the banks of Moose Creek; on Wishbone Hill, which is between Moose and Eska creeks; and on Castle Mountain and in the hills east of it. Since the coal-bearing rocks underlie the conglomerate, the areas of the conglomerate are included in the coal area as represented on Plate VIII and in the table on page 134, although there is no positive evidence as to whether workable coal is present in these areas.

The conglomerate is overlain unconformably on Castle Mountain by about 800 feet of volcanic rocks.

INTRUSIVE ROCKS.

Several large and many small masses of igneous rock have been intruded into the Tertiary beds in the valleys of Chickaloon and Kings rivers and elsewhere in the eastern part of this region. These intrusives are known in the valleys of Eska and Moose creeks only in the form of very small dikes and sills, except possibly on the northern border of the region. Gabbro, diabase, diorite, and several kinds of porphyritic and fine-grained rocks are known to be represented among these intrusives.

GRAVELS.

The Quaternary deposits of this region are of considerable diversity of character and cover broad areas. They include glacial morainic deposits, gravels laid down by glacial waters, terrace gravels more remotely connected with glacial agencies, and the alluvial deposits on the present flood plains.

The terrace gravels are of wide extent and thoroughly mask the underlying rocks up to an altitude of about 1,000 feet, except where the larger streams have cut gorges through the gravels. These gravels are of extreme importance in a consideration of the coal, because they conceal the underlying rocks over broad areas, thus making it very difficult to estimate the actual areas of coal lands or to determine the details of the stratigraphy and structure. The thickness of these gravels ranges from 300 feet or more down to the vanishing point.

COAL.

STRATIGRAPHIC POSITION AND SECTIONS.

The coal beds of the part of the Matanuska Valley here under discussion are all known to be of Tertiary age and to agree approximately in general stratigraphic position with the coal of the Kenai formation on Cook Inlet. They all occur within the middle local division of the Tertiary rocks as grouped in this report. Their exact position within this division has not been determined, but they seem to be in general distributed throughout the greater part of its thickness. Nothing definite is known concerning the persistence of individual beds or of groups of beds.

Detailed measurements of most of the known coal beds are available in previous publications,[1] to which the reader is referred for such information. The following sections record measurements of exposures which were not seen at the time the earlier work was done and represent practically all of the unpublished information relating to coal sections:

Section of coal bed on east bank of Coal Creek, about 1 mile above Matanuska River.

	Ft.	In.
Gray shale.		
Coal	4	7
Shale		2
Coal		3
Shale		½
Coal		8
Shale		1
Coal		7
Shale		2
Coal	1	7
Shale		1
Coal		11
Carbonaceous shale	2	5
Shale and coal, altered by intrusion		6
Total coal	10	7

Strike N. 67° E.; dip 65° NW.

[1] Martin, G. C., A reconnaissance of the Matanuska coal field, Alaska: Bull. U. S. Geol. Survey No. 289, 1906, pp. 18-25. Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: Bull. U. S. Geol. Survey No. 327, 1907, pp. 43-56.

Section of coal bed on north face of Red Mountain, elevation 3,600 feet (about 4 miles north of mouth of Young or Little Kings Creek or 3.4 miles west of U. S. L. M. No. 1).

	Ft.	in.
Shale with ironstone nodules.		
Coal, exposure obscure and thickness estimated	7	5
Shale		1½
Coal [1]	1	2
Shale		1
Coal [1]		6
Shale		1½
Coal [1]		7
Shale		¾
Coal [1]		4
Shale		½
Coal [1]		2
Shale		¾
Coal [1]	2	
Total coal	12	2

Strike N. 67° E.; dip 54° SE.

Another coal bed at least 5 feet and possibly 10 feet thick is poorly exposed about 30 feet stratigraphically above this, the intervening rocks being shale with ironstone nodules and sandstone. About 30 feet higher another bed of unknown thickness is present, and 50 feet still higher the smut of another bed was seen.

The presence of coal at this locality adds a hitherto apparently unknown coal area to the Matanuska fields.

Section of coal bed on east bank of Moose Creek, 4.1 miles north of its mouth.

	Ft.	in.
Carbonaceous shale with ironstone nodules.		
Carbonaceous shale with seams of bony coal	1	
Coal		7
Bone and shale		1
Coal		10
Bone		2
Coal		9
Shale with coaly streaks	7	
Coal	1	
Shale		1½
Coal		3
Shale		½
Coal	1	5
Bone		1
Coal		10
Nodular shale.		

Strike N. 65° E., dip 80° SE.

[1] Included in sample No. 11382F, p. 138.

COAL AREAS.

EXTENT.

The areal extent of the assemblage of rocks which carry the coal is indicated on the geologic map (Pl. VIII). The map shows also by a separate pattern the areas which may be underlain by these rocks but in which the lack of exposures caused by the presence of gravels on the surface or the indefiniteness of lithologic character of the exposed rocks makes it uncertain whether the coal-bearing rocks are present. These are the areas which may carry coal as distinguished from the areas which are known not to carry coal, represented by other patterns on the map. The areas of the "coal-bearing rocks" can not be assumed to be underlain wholly by beds of coal of workable character and thickness. Moreover, parts of these areas may have no coal under them. The lack of knowledge as to the exact stratigraphic position of the coal beds, the uncertainty as to what stratigraphic part of the "coal-bearing rocks" is represented by the various surface outcrops, and the concealment of the rocks by gravels over broad areas make the precise areal distribution of the coal a problem which can be solved only by drilling or other underground exploration.

The areas of the tracts which it is believed may possibly contain workable coal are indicated in the following tables. The first of these tables shows the areas known to be occupied by the "coal-bearing rocks," as defined above, and by the conglomerates and other beds which overlie them. The second table shows the areas which may also be underlain by these rocks but in which, because of concealment by gravels or because of other lack of definite information, there is a possibility that other formations may be present. These estimates are provisional and may be revised when the field notes are fully worked up.

Areas of supposed coal-bearing rocks.

	Square miles.
Valleys of Chickaloon and Kings rivers	44
South of Matanuska River, between Kings Mountain and eastern edge of area shown on Chickaloon special map	8
Valley of Young Creek	3
Valleys of Moose and Eska creeks	19
	74

Areas of possible extensions of supposed coal-bearing rocks.

	Square miles.
Lower parts of valleys of Kings and Granite creeks	8
Valleys of Moose and Eska creeks	16
	24

STRUCTURAL CONDITIONS.

It is not practicable in this brief report to present an adequate discussion of the structure of this region. This will necessarily be left for the detailed report. The general character of the structure is indicated in the sections on Plate IX. The coal-bearing rocks, like most of the other rocks of this region, have been strongly folded so that steep dips and complex structures are present throughout most of the area. In places there is a continued uniform dip for considerable distances, as is shown in section A–A′, Plate IX, but it is not known whether this condition means simple monoclinal structure or a repetition of parallel fault blocks. At other places there are frequent reversals of dip, but these may be due either to simple folding or to more complex faulting. In each of these cases the lack of definite knowledge concerning the type of structure is due to the absence of recognized characteristic strata from the distribution of which the actual structural details could be inferred.

In two areas within the field the type of structure is known with a fair degree of certainty. These areas are the ones occupied by the conglomerate in the vicinity of Castle Mountain and of Wishbone Hill. Here the clearly defined contacts of the conglomerate with the adjacent rocks, as well as the numerous individual beds of conglomerate, make it possible to determine the actual structural details.

The western end of Castle Mountain (see section B–B′, Pl. IX) is a monoclinal block having a dip of about 6° to 20° NE. The eastern end (shown in section A–A′, Pl. IX) is a syncline having a broad southern limb on which the dips range from 10° to 20° N. and a narrow, sharply upturned northern limb with dips of 60° to 90°. Possibly the northern limb of this syncline is cut off in the western part of the mountains by a fault, or on the other hand the structure may be dominantly monoclinal with local upturning of the strata along the fault in the eastern but not in the western part of the mountain.

Wishbone Hill is in general structurally similar to Castle Mountain. The eastern end (shown in section D–D′, Pl. IX) is a syncline pitching sharply toward the west. The western end is likewise synclinal, but the northern limb of the syncline has been cut by a fault in the western end of the hill and in the valley of Moose Creek, as is shown in section E–E′, Plate IX, so that the conglomerate mass as exposed on Moose Creek shows dominant northward dip and but for a few exposures showing gentle southward dip would appear to be a monoclinal block.

The points of dissimilarity between Castle Mountain and Wishbone Hill are that on Castle Mountain the entire northern edge is bounded by a fault which has brought the arkosic rocks beneath the coal into contact with the conglomerate above the coal, whereas on Wishbone Hill the fault is possibly absent at the east end so that the coal-bearing rocks encircle the end of the conglomerate mass, and at the west end the fault is not of sufficient magnitude to bring more than the coal-bearing rocks into contact with the conglomerate. The syncline at the east end of Castle Mountain pitches toward the east, whereas the one at the east end of Wishbone Hill pitches toward the west.

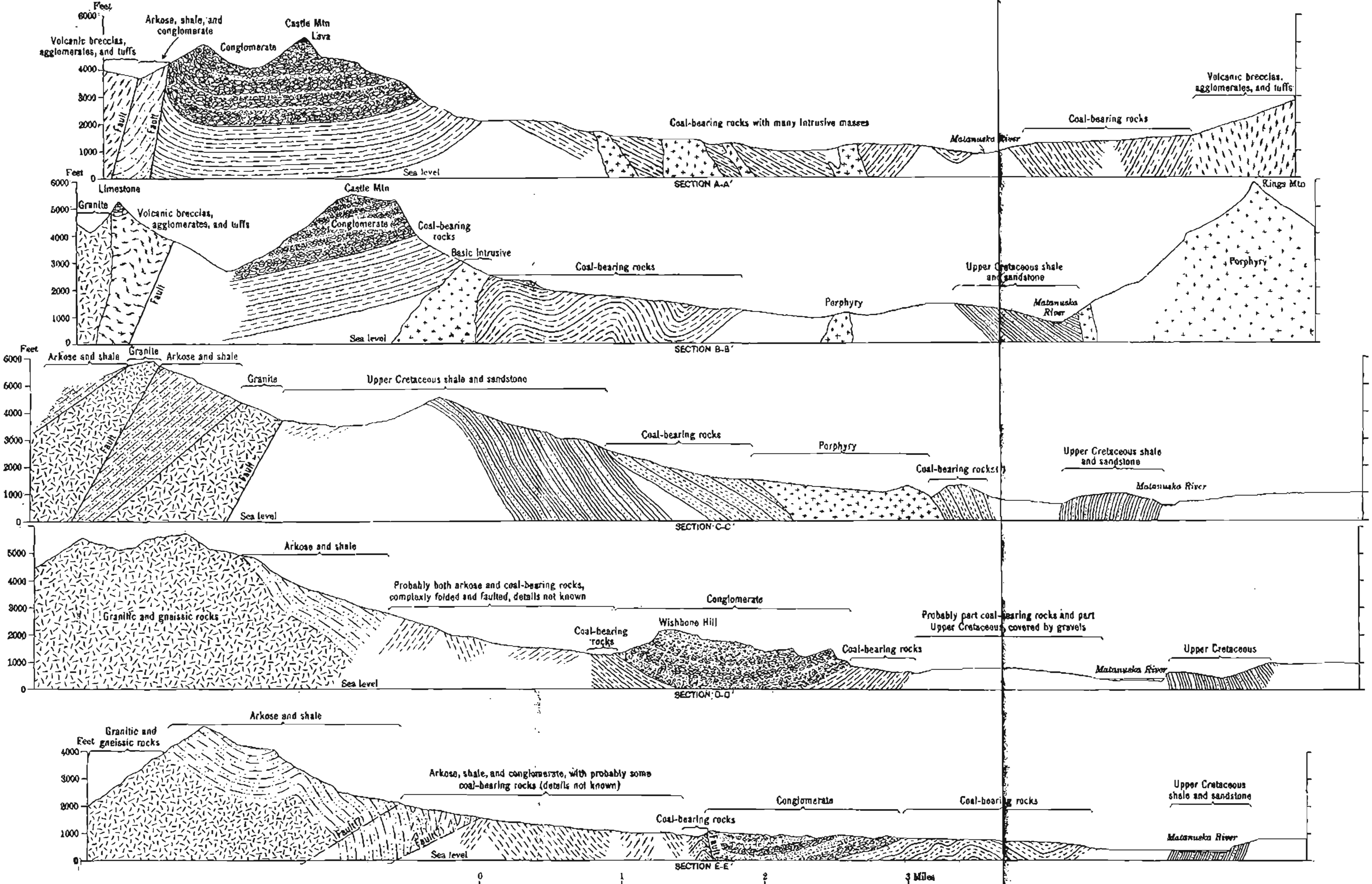
Both Castle Mountain and Wishbone Hill are of fairly simple structure, so that if the coal beds persist beneath the conglomerate, and if the coal-bearing rocks were not folded before the conglomerate was laid down, mining should be simple, at least as far as structural conditions are concerned.

It may perhaps be considered probable that the structures of the entire valley are of the same general type as those known in the areas of the conglomerate. If this is the case, there are probably large areas in which structural conditions will permit the mining of the coal. This condition can not, however, be definitely assumed to exist, and the character of the structure must be regarded as a problem to be solved by underground exploration before the feasibility of mining at a profit the coal of any particular tract can be demonstrated.

EFFECT OF INTRUSIVE ROCKS.

Intrusive rocks are present in abundance and in large masses throughout the greater part of the area of coal-bearing rocks except in the valleys of Moose and Eska creeks, where they are small and are much less numerous than farther east. The areal distribution of the larger of these intrusive masses is indicated on the map (Pl. VIII). Small dikes and sills, not represented on the map, are also present throughout practically all the coal areas. Where the intrusives cut the coal beds the coal is rendered worthless for a distance of a few inches from the contact. The small dikes and sills, on account of the short distance to which their effect extends, would not affect the coal seriously, except that the sills show a habit of seeking coal beds for their planes of intrusion. It is clear that if a sill is intruded into a coal bed for a long distance a large amount of worthless coal will result, whereas if it is intruded between rock strata, even if only a few feet away from the coal bed, or if it cuts across the coal bed in the form of a dike, its effect on the coal will be slight.

The larger intrusive masses are of much more serious importance than the small dikes and sills, first, because their size is sufficient to reduce the coal areas very considerably, and, second, because each of them is likely to have sent off many apophyses in the form of sills in or along the surfaces of coal beds. The dimensions of these masses are, moreover, probably greater beneath the surface of the ground than at the surface. There may also be many intrusive masses which do not outcrop but which are near enough to the surface to be encountered in mining.



STRUCTURE SECTIONS IN THE MATANUSKA VALLEY.

In conclusion, it must be stated that the presence of intrusive rocks in the coal field introduces factors which make an undetermined percentage of the coal areas of very doubtful value. The actual size and distribution of these intrusive masses beneath the surface, as well as at the surface in the areas of scanty outcrops, can not be determined without underground exploration. The effect of the smaller intrusive masses on the coal depends on the extent to which these have been intruded into or on the surfaces of coal beds. Where the intrusive mass is in actual contact with the coal the coal is worthless, but where it is a few feet away the quality of the coal is probably unimpaired or even may be possibly improved.

CHARACTER OF THE COAL.

The physical and chemical properties of the coal have been fully discussed in previous publications. This discussion will not be repeated in detail here. It is sufficient to state that the coal on Chickaloon and Kings rivers and on Coal Creek is high-grade bituminous and is probably at least in part coking coal, whereas that in the western end of the district, namely, on Moose, Eska, and Young creeks, is low-grade bituminous and is probably all noncoking coal. The anthracite described in earlier publications [1] is not known within the area here described but lies farther east.

The following table includes characteristic analyses from different parts of the area. The analysis of sample No. 11382F was taken during the investigations here described. The other analyses have been published in Bulletins 289 and 327 and represent samples collected in 1905. All the samples except Nos. 2215 and 2227 are from surface prospects or from outcrops and are consequently somewhat weathered. Samples 2215 and 2227 are from a tunnel at a distance of 43 to 58 feet from the mouth and probably under about 25 or 30 feet of cover.

[1] Martin, G. C., A reconnaissance of the Matanuska coal field, Alaska: Bull. U. S. Geol. Survey No. 289, 1906, pp. 18-19, 26-30. Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: Bull. U. S. Geol. Survey No. 327, 1907, pp. 52-56, 59-62.

Analyses and tests of Matanuska coal (samples as received).

Locality.	Laboratory No.	Thickness in feet.	Loss on air drying.	Proximate.				Ultimate.					Heating value.	
				Moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
Chickaloon River, tunnel No. 2[a]	2215	12.3	1.60	2.53	16.66	69.72	11.07	0.57	4.39	76.58	1.37	6.23	7,040	12,583
Chickaloon River, tunnel No. 3, selected sample[b]	2227	3.3	(c)	.99	19.60	73.59	4.79	.60	4.71	82.90	1.48	4.52	8,205	14,769
Coal Creek[d]	2217	5.0	.99	1.67	18.58	75.19	4.26	.50	4.90	82.79	1.79	5.66	8,140	14,652
Kings River[e]	2214	2.9	1.60	2.68	20.59	64.72	11.91	.28	4.68	74.26	.87	5.77	7,422	13,360
Red Mountain[f]	11062F	12.5	8.50	15.57	33.80	44.57	5.06	.22	6.41	63.14	1.13	23.01	6,236	11,225
Eska Creek[g]	2226	2.6	(c)	4.74	34.79	54.04	6.43	.43	5.54	71.86	1.40	14.97	6,985	12,573
Eska Creek[h]	2224	2.5	(c)	5.00	33.90	50.65	10.45	.41	4.77	63.59	1.38	19.40	6,332	11,400
Moose Creek[i]	2255	6.0	(c)	4.73	23.64	59.62	11.98	.38	4.76	64.09	1.09	17.70	6,428	11,570
Moose Creek[j]	2291	11.7	4.60	9.49	33.60	51.71	5.17	.25	5.82	63.95	1.20	23.01	6,445	11,601

[a] Bull. U. S. Geol. Survey No. 289, p. 21, sample No. 2.
[b] Idem, p. 21, sample No. 3.
[c] Not determined.
[d] Idem, p. 20, sample No. 6.
[e] Idem, p. 22, sample No. 13.
[f] This bulletin, p. 131.
[g] Bull. U. S. Geol. Survey No. 289, p. 21, sample No. 18.
[h] Idem, p. 24, sample No. 19.
[i] Idem, p. 25, sample No. 20.
[j] Idem, p. 26, sample No. 21.

A RECONNAISSANCE OF THE WILLOW CREEK GOLD REGION.

By Frank J. Katz.

INTRODUCTION.

Placer prospects were found in the Willow Creek region in 1898. Up to 1906 efforts seem to have been directed mainly to the development of the placers of Grubstake Gulch and Willow Creek. So far as the writer has been able to find out the first quartz-lode location was made in 1906 on the ridge between Willow Creek and Fishhook Creek. This was followed in 1907 by other locations on Fishhook and Willow creeks. In 1908 the field was extended on the west by locations on Craigie Creek, and in 1909 by locations to the north and east of Fishhook Creek, around the head basins of Archangel Creek, and on the mountain between that creek and Little Susitna River. Altogether some 60 claims are being developed and several other prospects have been located.

In September, 1906, Paige and Sargent, of the Geological Survey, visited Willow Creek in the course of a general reconnaissance of the Talkeetna region. Paige's descriptions of the geology and placer mining were published in 1907.[1] In September, 1910, after finishing the season's work with G. C. Martin in the Matanuska coal field, the writer, accompanied by Theodore Chapin, spent four days in the Willow Creek region. The observations made and the information collected by them are embodied in this report.

GEOGRAPHY.

Location and area.—The Willow Creek gold field is included in an area 10 miles square which lies in about longitude 149° 20′ west and latitude 61° 50′ north. It is approximately 20 miles northeast of Knik, a settlement on Knik Arm of Cook Inlet. The field occupies the southwestern part of the Talkeetna Range.

[1] Paige, Sidney, and Knopf, Adolph, Reconnaissance in the Matanuska and Talkeetna basins, with notes on the placers of the adjacent region: Bull. U. S. Geol. Survey No. 314, 1907, pp. 104–125; Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: Bull. U. S. Geol. Survey No. 327, 1907.

Topography and drainage.—The region comprises the divide between Little Susitna River and the south fork of Willow Creek and is divisible into a northern and a southern part. The northern part is a high, rough mountain mass, whose 6,000-foot summit is sometimes locally spoken of as "the Pinnacle," from which radiate the headwaters of Willow Creek and the western tributaries of Little Susitna River. The southern portion is a somewhat lower and less rugged ridge, called Bald Mountain, lying between the lower courses of Willow Creek and Little Susitna River.

From the central northern mountain Purches Creek, Craigie Creek, and the creek known as the "head of Willow Creek" flow west, southwest, and south-southwest, respectively, to Willow Creek. Fair Angel Creek and Fishhook Creek head against the same mountain and flow southeast and south, respectively, to Little Susitna River. Little Susitna River flows south along the eastern part of the region to the Matanuska Valley and turns west, following the base of Bald Mountain and receiving from it many small tributaries.

The important streams of the northern part of the district are Archangel Creek, with its branches, and Fishhook Creek, which are tributary to Little Susitna River, and Craigie Creek, the "head of Willow Creek," Grubstake Gulch, and Wet Gulch, tributary to Willow Creek. Archangel Creek is a westerly tributary of Little Susitna River. About 1½ miles above the river it forks. The northern branch is known as Reed Creek and the eastern as Fair Angel Creek. Fair Angel Creek heads in several cirques on the east and northeast side of "the Pinnacle." It is about 2½ miles long and has a southeasterly course. Its basin is U-shaped and from 2,400 feet to 3,400 feet in altitude. Fishhook Creek is south and west of Fair Angel Creek. It flows south about 3 miles from a large compound cirque on the south of "the Pinnacle" and then bends sharply east to Little Susitna River. It occupies a U-shaped basin from 2,000 feet to 4,000 feet high and hangs about 300 feet above Little Susitna River. The "head of Willow Creek" is west of Fishhook Creek and occupies a glacial trough 3,000 to 4,000 feet high and about 2 miles long. It flows southwest to Willow Creek (south fork) proper, which flows west. Craigie Creek has a U-shaped valley west of the head of Willow Creek. Its basin is from 2,500 to 3,500 feet high and about 5½ miles long, directed toward the southwest. It hangs about 400 feet above Willow Creek.

The ridges between these streams are narrow, high, and rugged, with steep, craggy upper slopes. Between the head cirques are very sharp arêtes.

In the southern part of the district the important streams besides Willow Creek and Little Susitna River are those in Grubstake Gulch and Wet Gulch, tributaries of Willow Creek. These gulches are glaciated basins about 3 miles long, heading against the north side of the summit of Bald Mountain. There are four minor streams on the north side and a dozen or more small gulches on the south side of this ridge.

Climate.—There are no recorded observations on the climate of Willow Creek region. It may be said, however, that conditions are in general the same as in the lower Matanuska [1] and Susitna basins, with perhaps a slightly heavier precipitation and shorter summer. In 1910 snow lay on some of the prospects at high altitudes, delaying development work until August.

Water supply.—There is little perennial snow in the district, yet considerable ice persists in the broken rock and talus of the higher mountains. From these sources the streams in the northern part of the region were kept high enough during the dry 1910 season to run such small mills as have been erected. Craigie, Willow, Fishhook, and Fair Angel creeks appear to have during the summer sufficient volume and fall to run prospecting and small development mills for the claims located on them. Large power development is possible at the canyon of Little Susitna River, which is less than 10 miles from the farthest prospect.

For the hydraulic placer mining on Grubstake Gulch the creek has in ordinary years furnished ample water, in rainy years more than could be handled, but in an exceptionally dry season it has failed.

Timber.—In the Willow Creek basin there are no trees above the mouth of Grubstake Gulch and no good spruce above the mouth of Wet Gulch. On Little Susitna River good spruce is about a mile below the mouth of Fishhook Creek. The lumber supply is plentiful and good in the lower parts of the Willow Creek and Little Susitna River valleys. The heads of the streams at the prospects are devoid of alders and willows. The gold-quartz prospects are 4 to 8 miles from building and mine timbers, and even brush for fuel must be hauled or packed at least half that distance.

The Matanuska coal field, which is 25 to 50 miles by trail from the Willow Creek prospects, has furnished forge coal and is a prospective source of fuel for the region. Lignite is reported nearer by, on lower Willow Creek.

Routes.—There are three routes from Knik to the Willow Creek district. One trail which is used only in the winter goes north from Knik around the western end of Bald Mountain to and up Willow Creek. By this route it is about 30 miles to the mouth of Craigie Creek. The old summer trail to Willow Creek takes a northeasterly direction through Cottonwood to Bald Mountain, crosses Bald Mountain at an altitude of 3,400 feet, and goes down Wet Gulch to Willow

[1] Martin, G. C., Reconnaissance of the Matanuska coal field, Alaska, in 1905: Bull. U. S. Geol. Survey No. 289, 1906, pp. 7-8.

Creek. This route is about 26 miles. The third route is a fair wagon road which can be used throughout the year. It leaves the winter trail near Knik and strikes northeasterly across the lowlands to Little Susitna River. It crosses to the west bank and follows up the river to the mouth of Fishhook Creek. The distance is 28 miles. The usual route traveled from Knik to Fishhook Creek in summer follows the old Willow Creek summer trail to the wagon road and then the wagon road. There are trails from Willow Creek at Wet Gulch to and up Craigie Creek, to Grubstake Gulch, and up to the head of Willow Creek. From the head of Willow Creek a trail crosses the divide between Willow and Fishhook creeks through a saddle somewhat lower than 4,000 feet. From the mouth of Fishhook Creek trails lead up Fishhook and to the head of Fair Angel Creek.

GEOLOGY.

The distribution of the rocks, which is shown on the accompanying sketch map (fig. 18), may be summarized as follows:

A line drawn west from the pass between Willow and Fishhook creeks and along the north side of Willow Creek marks the contact of a large area of quartz diorite on the north and mica schists on the south. North of Willow Creek the country rock, which is locally called granite, is light colored, of granitic texture, and composed of feldspar (chiefly plagioclase), quartz, hornblende, and biotite. It is uniform in composition and texture. Quartz diorite is scientifically a more accurate name for the rock than granite. There are a very few basaltic (diabase?) and aplitic dikes of small size cutting the quartz diorite. South of the quartz diorite as far as the summit of Bald Mountain and west of Little Susitna River the rocks are thoroughly foliated mica schists. The schistosity has a prevailingly southward dip. Quartz stringers are commonly seen in these schists. On the south flanks of Bald Mountain and the mountain opposite it east of Little Susitna River are Tertiary arkoses, sandstones, and shales. Along the northern limit of the Tertiary area some of the arkoses, which are sedimentary rocks composed of disintegrated granitic material, so closely resemble the granite or diorite adjacent to them that their differentiation in the field requires considerable care. A narrow tongue of granitic rocks appears to lie along the top of Bald Mountain between the Tertiary sediments and the schists. The Tertiary sediments lie unconformably with southerly dip on the quartz diorite east of Little Susitna River and are probably in like relationship on Bald Mountain. The quartz diorite appears to be intrusive into and largely to surround the schists. A small amount of basalt was noticed on the summit of Bald Mountain west of the head of Wet Gulch.

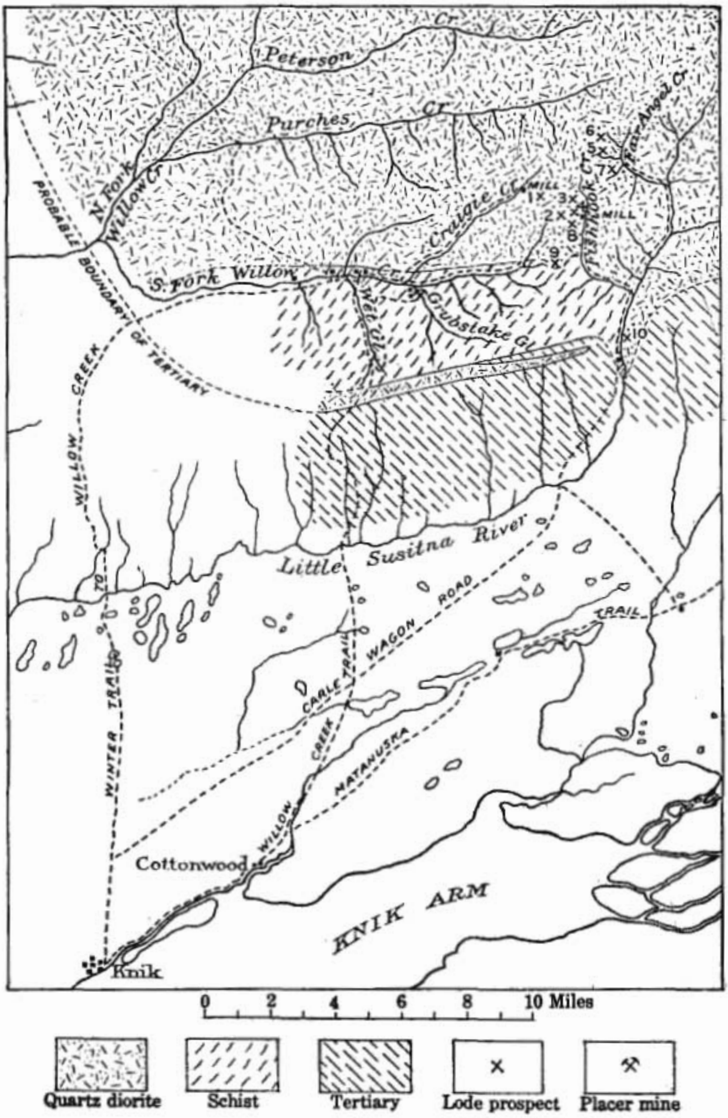


FIGURE 18.—Geologic sketch map of Willow Creek region.

1. Gold Bullion Mining Co.
2. Brooklyn Development Co.
3. Gold Quartz Mining Co.
4. Free Gold Mining Co.
5. Matanuska Gold Mining Co.
6. Conroy & Marrion group.
7. Fiske & Reed group.
8. Bartholf-Isaacs group.
9. Lydell prospect.
10. Miller prospect.

Recent glacial and stream deposits are present in all the valleys. Terraced gravel benches line the lower portions of Willow Creek and Little Susitna River.

MINERAL RESOURCES AND MINING DEVELOPMENT.

INTRODUCTION.

The mineral resources of the Willow Creek region are gold placers and gold-bearing quartz lodes. In 1906 Sidney Paige, of the United States Geological Survey, spent two days on Willow Creek and in its vicinity. Descriptions of the gold placers as then developed have been published in the reports by Paige and Knopf.[1] The gold lodes of the region had not been examined by the Geological Survey prior to the visit upon which the present report is based. Such information as could be gathered from reliable reports of prospectors and others interested in the region was summarized and published by Brooks.[2]

GOLD LODES.

GENERAL DESCRIPTION.

As the writer's time in the Willow Creek region was limited to four days, only the more developed prospects were visited. The following account is therefore incomplete.

The important prospects all lie north of Willow Creek in the area occupied by quartz diorite. In this area there are a few small dikes of diabase and aplite. At one prospect only are dikes (aplite) intimately associated with the ore body. The quartz diorite throughout the region is very much jointed. The most prominent and also the dominant systems of joints, which strike N. 40° W. (dip 20° to 40° SW.) and N. 30° E. and N. 60° W. (nearly vertical),[3] cut the rock into huge rhombohedral blocks that form a striking feature in the topography. At higher altitudes the rock does not decompose and disintegrate. Denudation appears to be largely accomplished by the dislodging of joint blocks. The quartz diorite mountains everywhere in the Willow Creek region and as far back as one can see into the Talkeetna Range are consequently marked by peculiar blocky or tilted steplike forms. Single fissure planes are visibly traceable for long distances. Movements along these planes are here and there indicated by slight crushing and slickensiding and do not appear to be important except in so far as they opened the fissures.

The ore bodies of the region, with the exception to be noted below, are quartz fillings in fissures having as a rule sharply defined walls, there being commonly from a small fraction of an inch to 2 or 3 inches

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[1] Paige, Sidney, and Knopf, Adolph, Reconnaissance in the Matanuska and Talkeetna basins, with rnotes on the placers of the adjacent region: Bull. U. S. Geol. Survey No. 314, 1907, pp. 116–118; Geologic econnaissance in the Matanuska and Talkeetna basins, Alaska: Bull. U. S. Geol. Survey No. 327, pp. 65–67.

[2] Brooks, A. H., The mining industry in 1909: Bull. U. S. Geol. Survey No. 442, 1910, pp. 35–36.

[3] These directions are approximate only and are referred to the magnetic north, declination 28° 38′ E. at Knik, 1906.

of clayey decomposed diorite along the quartz. Many narrow quartz-cemented breccias of the wall rock have been found along or within the veins. The quartz is white and bluish gray, in many places banded and giving evidence of having been broken and recemented along planes roughly parallel to the walls. The veins lie for the most part along fairly regular plane fissures that are persistent, so far as present developments establish absolutely, through several hundred feet, and some are reported to have been traced for several thousand feet. There are also quartz veins or stringers in irregular, less persistent small fissures which are being prospected. These veins are from 1 or 2 inches to 4 feet in thickness. The smallest one which has been located as a "lode," so far as the writer saw them, is 16 inches thick. With few exceptions within the region proper the veins strike nearly northwest with moderate southwest dip.

There is little visible mineralization in most of the quartz. Much pure-white quartz not only assays high but will yield colors on panning. Considerable quartz with abundant visible gold has been found. Here and there on the veins of all the prospects examined minute and sparsely scattered specks of pyrite and other undetermined minerals were found. Tellurides have been reported by several of the operators. However, in none of the material seen by the writer was the supposed telluride mineral sufficient in amount or in grains large enough to be recognized. The surface material is all very slightly porous and rusty. The Geological Survey has made no assay of these ores. The gold content of these veins, as indicated by mill tests and assays reported by the prospectors and owners, is very high. The superintendent of the Gold Bullion Co.'s plant reports $35,375.54 received from 226 tons. Most of this was free-milling gold. High values are reported in concentrates and tailings. Reports of assays of individual samples from other prospects indicate values between $30 and $40 a ton and higher, and all are free milling. All the material thus far examined is from the surface or from points less than 150 feet from the entrance of the adits.

The foregoing discussion applies to the quartz diorite area where quartz lodes are being developed. In the adjoining schist area, particularly on Grubstake Gulch, are gold placers. Concerning the origin of the placer gold, Knopf and Paige in the reports cited state:

> The origin of the gold may be ascribed with certainty to the abundant quartz stringers in the mica schists. The coarseness and roughness of the gold suggest a near source of supply. * * * The fact that placer gold has not been found in paying quantities where streams have headed in granitic or other crystalline rocks bears out this statement.

Recent developments have thrown no light on this problem. It is still true that there are no paying placers in the area of granitic rocks which contains the quartz lodes of the region, but the valleys of that area are heavily strewn with coarse glacial débris, are farther from timber than Grubstake Gulch and hence are not attractive to the placer miner; furthermore, the prospectors' attention has been concentrated on the lodes. The writer, however, believes that the above quotation ascribes the origin of the placer gold to a source which is not inadequate.

It appears, then, that besides the occurrence of gold in the diorite in veins, large and persistent enough to make workable lodes, gold may also occur in the schist in rather widely distributed small bodies which yield placers.

DESCRIPTION OF THE PROSPECTS.

Craigie Creek.—The Gold Bullion Mining Co. is developing a group of five claims near the summit of the ridge on the south side of Craigie Creek about 5 miles from the mouth of the creek. The lode lies at an altitude of about 4,500 feet, or roughly 1,500 feet above the valley bottom. The mountain slope below the prospect is mantled by glacial débris and talus which contains a great deal of vein quartz in large and small pieces. At and above the prospect there is some talus and the bedrock is considerably disrupted, disturbed, and loosened by weathering (chiefly frost heave). The development work has consisted largely of cleaning out the loosened surface material in order to uncover the lode in firm bedrock. The quartz sorted out in this work has constituted the larger part of the "ore" handled. Through a distance of 3,000 feet several patches of gold-bearing quartz have been encountered. The vein or veins are about 2 feet to 2½ feet thick. Two open cuts and a short adit have been made which show such veins, but all of these were more or less obscured at the time of the visit. A breakdown of the aerial tram had stopped work for about a month and the openings had been permitted to become covered by slide. It seems that the openings are along a single vein or vein zone whose outcrop has an east-west (magnetic) trend and low dip to the south, but this has not been definitely established by the workings.

The ore is quartz in which a little free gold and small specks of sulphides are visible. The quartz is dominantly white but in some places slightly rusty and in others bluish. In some pieces quartz diorite was seen "frozen" to the quartz, but in general both the quartz and the quartz diorite are crushed and seamed parallel to the walls and there is some slickensiding and gouge along the walls.

The Gold Bullion Mining Co. has erected a 2-stamp mill, capacity about 6 tons a day. The mill is run by water power, amply sufficient for five more stamps, which the company intends to install during the winter of 1910–11. A light aerial tram was used to bring the ore down over the high steeper slope of the mountain, below which the ore was dragged in stone boats for about 100 yards by horses. All wood for building, timbering, and fuel must be either dragged or packed by horses from at least 6 miles below the mill.

Willow Creek.—The Brooklyn Development Co. has 11 claims in and around the basin at the head of Willow Creek. Development work has been confined to one of the claims near the summit of the ridge on the east side of the basin. Here there are three small cuts and an adit 150 feet long. The quartz diorite is much broken up by joints striking from N. 40° W. to N. 65° W. with dips southeast from 23° to nearly vertical. Along the fractures the quartz diorite is much crushed and weathered to clay. Quartz lenses and stringers of small size were seen in the fractured quartz diorite shown in the cuts and in the adit. On the dump at the adit larger chunks of quartz indicated that a vein had been cut (probably near the entrance and now covered by timbering so that it was not seen). This quartz is rusty and shows small scattered specks of pyrite and galena(?). It is reported that the adit was started on a vein with low dip which carried it above the adit. At a number of points along the adit the quartz diorite is fractured, crushed, and much decayed. There are small quartz veins in these fractured parts. The reported values are high.

Fishhook Creek.—The Alaska Gold Quartz Mining Co. operates a group of claims, locally known as the Carle prospect, on the Fishhook Creek side of the ridge between Willow and Fishhook creeks about 3½ miles above the mouth of Fishhook Creek. The prospect is on the steep wall of a small cirque several hundred feet above the level of the main valley floor. The prospect is a quartz vein which has been exposed by stripping the débris along the face of the mountain through 300 or 400 feet. An adit has been driven 150 feet on the vein.

The vein strikes approximately N. 52° W. (magnetic) and dips 24° SW. It is not perfectly plane and its thickness is slightly variable but averages about 2 feet. At 147 feet from the entrance the vein is broken by a dip fault of large hade and 4-foot throw.

The quartz is in part banded, white, gray, and dark bluish, carrying scattered minute sulphides (?), and in part very white, massive, and free from visible mineralization. The walls are sharply defined and generally smooth, with a gouge or clay from a small fraction of an inch to 2 and 3 inches thick. Along the borders of the vein are numerous angular fragments of granite, commonly very much decomposed, included within the vein filling.

All parts of this vein are reliably reported to yield free gold by panning.

Besides stripping between 300 and 400 feet along the outcrop and driving an adit 150 feet on the vein, the company has put up, on Fishhook Creek, a small water-power 2-stamp prospecting mill without concentrators and has built a trail over the steep mountain face between the prospect and the mill.

Adjoining the Carle prospect on the south and the Brooklyn Development Co.'s property on the east is the Thomas prospect. This is operated by the Free Gold Mining Co. At about the same altitude as the Carle a vein of quartz has been stripped for 500 feet or so along its outcrop. The vein, which strikes N. 40° W. (magnetic) and dips 36° SW., has been entered by a slope adit. This was partly filled with water, so that only the upper part of the opening could be seen by the writer. The vein is about 16 inches thick and in every way similar in appearance to that on the Carle prospect, of which it may be an extension.

Besides the Carle and the Thomas prospects on Fishhook Creek there are several others which were not visited by the Survey party. Quartz from which gold can be obtained by panning has been found all around the Fishhook basin. On the divide between Fishhook and Fair Angel creeks the Reed & Fiske claims have been located. A large number of open cuts on this property indicate a quartz vein continuous for 300 feet, averaging 4 feet wide. The vein in some places includes a granite breccia and has gouge or clay along the walls. The strike is N. 40° W. (magnetic); the dip 30° SW.

Fair Angel Creek.—The Matanuska Gold Mining Co. has begun work on a group of four claims near the head of Fair Angel Creek. The prospect is near the top of a steep cirque wall and is at an altitude of about 4,500 feet, which is 1,500 feet above the camp in the valley bottom. In the neighborhood of the prospect aplitic dikes were seen in the "granite." The "vein" is an aplitic or pegmatitic dike, in places 9 feet thick, striking N. 60° W. (magnetic) and dipping 52° NE. This rock is a whitish or pinkish quartz-feldspar rock, with a few scattered black minerals, hornblende, and apparently also tourmaline. The dike has been shattered and cemented by quartz, especially along the hanging wall, where there is locally 8 inches of vein quartz. Between this and the granite is a narrow gouge seam. The values appear to be associated with the vein quartz, in which small specks of sulphide minerals are visible. The granite wall is everywhere more or less decayed and is said to carry values.

Two small open cuts were made on the "vein" during 1910. A tunnel was to be driven during the winter of 1910–11.

The Conroy claims adjoin the Matanuska Gold Mining Co.'s property on the north. The prospects lie on a ridge separated from those of the Matanuska Gold Mining Co. by a small cirque. There has been no work done on these claims except a little stripping of loose rock from the vein or veins at several places. At one such place the amount of quartz exposed is small. At another the indicated strike is N. 40° W. (magnetic) and the dip southwest. In attitude of the vein and appearance of the quartz this prospect corresponds with the commoner type of the district and not with the adjoining Matanuska Gold Mining Co.'s prospect, which is exceptional.

Outlying prospects.—Some claims have been located outside of the main quartz diorite area. Among them are the following:

The Lydell claim is in the pass between Willow and Fishhook creeks, on the contact of the quartz diorite and the mica schists. This claim was not visited by the Survey party. However, from reliable sources it was learned that there is a large quartz vein along the contact and a number of smaller quartz stringers in the schist. So far as at present known there are no important mineral values in this prospect.

The Miller claims are in the Little Susitna River valley. One on the east bank is about 2 miles below the mouth of Fishhook Creek. There is here a mass of quartz between 60 and 80 feet thick; the upper wall is brecciated and much-altered quartz diorite(?). The lower wall was not exposed. The trend of the quartz mass appears to be N. 20° W. (magnetic) and it is either vertical or dips about 28° SW. The locator is engaged in crosscutting the quartz. The "ore" is bluish-white fine granular quartz with sparsely scattered pyrite crystals. So far as known the ore carries no gold values. The occurrence is most probably a quartz-filled brecciated fault zone. It is said to be traceable for 3 miles along Little Susitna River.

Mr. Miller has another claim on the west side of Little Susitna River about 3 miles below Fishhook Creek. This was not visited and no satisfactory information about it was obtained.

SUGGESTIONS FOR FURTHER PROSPECTING.

The prospects thus far located around the heads of Craigie, Willow, Fishhook, and Fair Angel creeks are all high on the cirque walls or narrow ridges between cirques. There seem to be two reasons for this restriction in area and altitude. First, the prospecting has been limited to the region nearest to and most readily accessible from the supply point, Knik. Second, the lower slopes and creek basins have been mantled by glacial débris, talus, and moss, which make the surface-examination method of prospecting practiced in the district impossible at lower altitudes. The ridge crests on which the prospects are located have been exhumed by glaciation from considerable depths, and it is probable that the phenomena of fracturing and veining thus exposed are present at lower altitudes also. The wide extent and persistent character of the joint systems, so strikingly apparent in the surrounding mountains of the same country rock, suggest that some of the veins associated with the joints may also have as wide a distribution, both areally and at lower levels, and that at a given locality there may be veins at several elevations. For these reasons, and because the veins are not steeply inclined, prospecting by drilling and sinking shafts appears advisable.

GOLD PLACERS.

The placers are on Grubstake Gulch and on Willow Creek below Grubstake Gulch, both along the creek and on a bench on the south side (left limit) of the creek. Placer gold has been mined in commercial quantities at only one locality within the region—that is, on Grubstake Gulch. Willow Creek proper was staked by M. J. Morris and L. Herndon in 1898, and it is reported that they extracted about $4,000. In 1899 A. Gilbert staked Grubstake Gulch, and in 1900 he sold his interest to O. G. Herning, who manages the property for the Klondike Boston Mining Co., of Boston, Mass. This company also controls ground on Willow Creek and a bench below Grubstake Gulch. W. E. and E. H. Bartholf own most of the other claims on Willow Creek near Wet Gulch and below.

Grubstake Gulch is a glaciated hanging valley tributary to Willow Creek. Near its mouth a rim of bedrock crosses the channel and is cut through by the present stream, which falls precipitously for about 150 feet in a very short distance and enters Willow Creek at low gradient. An excellent dump for hydraulicking is thus afforded. The bedrock is a mica schist penetrated by small veinlets of quartz, both across and parallel to the schistosity. The parallel veinlets or lenses are the more abundant. Some of them have a pegmatitic aspect, but this could not be established in the rusty, weathered field specimens. The schistosity on the gulch has a strike about N. 60° E. (magnetic) and a dip of 40° N. The direction and inclination of the beds across the stream and the dip downstream are especially favorable for the collection of any gold that might have been concentrated from the rocks in the process of erosion.

Mining was begun above the falls. In the years 1904 to 1909, during which hydraulic methods have been in use, 1,200 feet of the creek with an average width of 200 feet and a depth from 2½ to 9 feet and locally (on the terrace on the west side) 12 feet have been worked out. The bedrock slope is about 1 to 24, or flume grade (6 inches to the 12-foot box). About one-third of the gold is coarse and rough, averaging one-tenth inch in diameter; the balance is moderately fine. The gold assays at the mint $16.58 an ounce. Very little black sand is found. In the lowest portion of the pay streak the gold was on a clay above bedrock, but higher up the creek the clay was absent. The greater part of the gold occurs close to or in crevices of the bedrock, but it is not deemed necessary to clean up by hand, the hydraulic giant being relied on to sweep all the gold into the boxes.

The wash, which is confined to the gulch bed—there being no bedrock bench, although the terraced surface of the gravels is spoken of as a bench—is coarse, ill sorted, and not greatly waterworn. The many large bowlders make it necessary to employ two men in breaking up and removing oversize and add materially to the cost of extraction. Three Hendy giants are installed on the property, two No. 2 and one No. 1. The No. 1 is not ordinarily used. Seven hundred inches of water with a head of 180 feet is brought three-fourths of a mile down the gulch. A 24-inch pipe at the intake dam is reduced to 9 inches at the giant, to which is fitted a 3-inch nozzle. Twelve hundred feet of sluice boxes have been built. These are 27 inches wide, 30 inches deep, with bottom boards $1\frac{1}{2}$ inches thick and side boards 1 inch thick; the frames are 3-inch square timbers. Block riffles are used. The gravel is driven to the boxes by the giants, at least one of which is directed across the creek—that is, parallel to the bedrock crevices. Very little gold is caught below the fourth box, the greater part being retained in the second. Mercury is placed in the third, fourth, and fifth boxes.

During 1910 the Grubstake Gulch operators limited their work to the extension of their pipe line about one-fourth mile and making other preparations for hydraulicking the bench at the mouth of Grubstake Gulch.

A ditch was built a few years ago from Wet Gulch down the south side of Willow Creek for the purpose of exploiting terrace gravels along Willow Creek. This project apparently has been abandoned.

SUMMARY.

The Willow Creek region is an area about 10 miles square some 20 miles northeast of Knik, on Knik Arm of Cook Inlet, Alaska. It includes an area of quartz diorite which is intrusive into and surrounds a belt of mica schist in its southern part and which is overlapped by Tertiary sediments along the south border of the region. The quartz diorite is cut by a few small dikes of diabase and aplite. A regular system of definite and continuous plane joints has broken the quartz diorite into blocks roughly rhombohedral in shape. There are other less regular and persistent joints, and along some of both the regular and the less regular joints there have been movements, but there are no observed faults of large displacement. Quartz filling of the fractures and decomposition of the quartz diorite along the fractures are not restricted to any set of joints, but, so far as this investigation determined, seem to be more extensive along those irregular fractures which are nearly vertical and trend approximately north and south, and along joints which strike approximately northwest (magnetic) and dip 20° to 40° SW. The latter is the most frequent veining and that which is of greatest importance to the region. The important prospects thus far located are on such veins, which are from 16 inches to 4 feet thick, and are demonstrably persistent through distances that warrant development. They carry small amounts of pyrite and other minerals and considerable free gold, much of which is visible in the quartz. So far as developments now show, the ores are free milling and high grade, and it appears not improbable that the mineral-bearing veins may be found over a wider area and at lower altitudes than those now located.

PLACER MINING IN THE YUKON-TANANA REGION.

By C. E. Ellsworth and G. L. Parker.

INTRODUCTION.

It is the object of this report to give a brief summary of the general progress of placer mining in the Yukon-Tanana region during 1910. The writers were engaged in a water-supply investigation of the Fairbanks, Circle, Tenderfoot, Eagle, and Seventymile placer districts of the Yukon-Tanana region, and incidentally some notes on mining operations were made. Much of the material embodied in this report, however, is due to information furnished by mine operators and others personally familiar with the conditions in the several districts.

The decrease in the value of the gold production of the Yukon-Tanana region from $10,720,000 in 1909 to $7,100,000 in 1910 can be attributed almost entirely to the drop in output from the Fairbanks mines, which in turn was due mainly to the fact that many of the richer placer deposits so far located have been worked out, although several other reasons of less importance contributed to the decrease. Every camp in the region furnished to a greater or less degree its quota of men and capital to the Iditarod district, and the increased interest taken in lode mining also drew many men away from the placers. There was also experienced in July and August the most severe drought that has occurred during that season since the beginning of water-supply investigations in this region in 1907. The successful operation of placer mines is so dependent upon the water supply that a shortage in that most important factor will inevitably result in a corresponding decrease in gold output.

FAIRBANKS DISTRICT.

GENERAL CONDITIONS.

The marked decrease in production in this district from $9,650,000 in 1908–9 to $6,100,000 in 1909–10 is due to several causes, chief among which is the fact that many of the richest pay streaks have been worked out. New discoveries and the tracing of old pay streaks have not furnished new ground sufficient to offset the amount worked out during the previous years. In other words, the district is reaching the stage in its development that lies between the exploitation of the rich bonanzas and the installation of machinery for large-scale operations which make for economy in extracting the gold from the gravels. This period of decline is experienced by most placer camps, and the interval of lower production will be long or short according to the difficulties met in making a thorough investigation of conditions and in perfecting organizations for the purpose of applying equipment best suited to the recovery of gold from gravels carrying low values. The exodus of men and machinery to the new Iditarod country also operated to cut down the annual output of the district, for many experienced miners transferred their funds and personal attention to the new placer camp. It was estimated that 1,000 men followed the ice down the Yukon to the new strike and, although many returned later, a disquieting effect was produced which was felt throughout the season.

The scarcity of water for sluicing necessitated the closing down of a number of plants and a reduction of the force employed at many others. The data secured during the summer at a number of stations on streams in the district (see p. 181) indicate a relatively lower run-off during July and August than has been recorded for any year since stream-flow investigations were begun in this section, in 1907. Still another reason for the decrease in the gold output may be the greatly increased activity in prospecting and developing quartz lodes in this vicinity, which has diverted the efforts and capital of a considerable number of experienced operators from placer mining.

Mining methods and conditions were practically the same as in previous years, and no great advance was effected in reducing the high cost of working the gravels, but some steps were taken to develop dredging ground. It is estimated that in 1910 between 1,300 and 1,400 men were employed in actual placer mining in the district on about 140 claims.

GOLDSTREAM BASIN.

During the winter of 1909–10 and the summer of 1910 Goldstream Valley presented a lively scene of mining operations from a point near the head of Pedro and Gilmore creeks to "No. 17 below." Open-cut methods were used extensively in the upper portion of the valley, where the depth of the ground permits working in this manner. Two large open-cut plants, one on "No. 9 below" Pedro and the other on "No. 5 below" Goldstream, operated bottomless scrapers successfully. It is reported that the cost of working the ground was less than 30 cents a square foot, which is low for the Fairbanks district. Several other smaller plants operating on Pedro Creek also proved the economy of the open-cut method of mining. The usual practice of drifting and hoisting was employed exclusively on lower Goldstream and Engineer creeks. Probably 90 per cent of the production of the Goldstream Valley was secured in this manner. In size the plants ranged from a hand windlass worked by 2 men to a 60-horsepower steam plant employing 40 men. Some difficulty was experienced on Engineer Creek with thawed ground and underground water, but the most serious drawback of the season in this basin resulted from the scarcity of water for sluicing. Several of the mines working on low-grade gravel were compelled to shut down entirely on this account, and a number of others were not able to work a full force during the low-water period.

Successful prospecting on the second tier of benches on the left side of Goldstream, opposite "No. 8 below," early in the spring led to the development of a good pay streak extending over three claims opposite "Nos. 7, 8, and 9 below" later in the season. Considerable prospecting was done during the summer and is still being done to trace the pay gravel farther up and down stream. Bedrock on the second tier and creek claims is at about the same elevation, but the pay streak above the former seems to be of a uniformly higher grade than in the creek bed. The depth of ground, however, is somewhat greater on the bench claims, as the average depth of hole is between 100 and 110 feet. It is estimated that 500 men were employed in placer mining on 52 claims on Goldstream, Engineer, Pedro, and Gilmore creeks during the winter season and probably about 20 per cent more were working during the summer months.

CHATANIKA RIVER BASIN.

Cleary Creek.—A large percentage of the annual gold production of the Fairbanks district continues to come from Cleary Creek, which has produced more gold than any other creek in the Yukon-Tanana region. The settlement of the legal status of "Nos. 4 and 5 below" in 1909 made it possible to resume working in the richest part of the creek. The large plant on "No. 5 below" employed between 50 and 60 men. Practically all the claims from "No. 10 above" to "No. 17 below" on Cleary were being worked during the winter, and in the spring there were between 40 and 50 large dumps to be sluiced with the spring run-off. The summer operations, though not so extensive on the upper portion of the creek, were of greater magnitude than those of the winter season on the lower portion. This was largely brought about by the Chatanika ditch, which furnished eight operators with all the water that was needed for sluicing. Several of the operators made use of electrical energy supplied by the Poker Creek power plant for pumping the water from the ditch to their sluice boxes set at a higher elevation.

Wolf Creek, which was prospected rather thoroughly in 1909, began to yield good returns in the spring of 1910. Both open-cut and drifting methods were employed in extracting the gold. The success attained by several small outfits engaged in "sniping" during the summer drew attention to the possibility of profitably working over the old tailings. It is conceded that the ground on Cleary Creek is of too great depth to work by hydraulic methods; but it is thought by local men that the gold remaining in the tailing piles amounts at least to 10 per cent of the quantity already recovered and that it might prove profitable to resluice the tailings with suitable appliances if the water from Chatanika River could be diverted to the ground at sufficient elevation and at a cost to warrant such an undertaking.

On Cleary Creek and tributaries between 45 and 50 outfits were working on about 30 claims during the winter.

Dome Creek.—A great decrease in mining operations was shown on Dome Creek, which has held a very prominent position among the producing creeks in past years. This is due chiefly to the exhaustion of the richest claims; but the fact that several of the claims are tied up in court proceedings is also an important factor. There were six or seven plants being operated between "No. 7 above" and "No. 7 below," of which only two on "Nos. 5 and 6 below" were working on a scale comparable to past operations. The extreme drought also added to the difficulties on this creek. It is said that there was scarcely enough water to supply a boiler on "No. 6 below" during the low-water period, where in former seasons there was very seldom less than a sluice head available. Further prospecting this year between "No. 7 below" and "No. 14 below" has failed to locate the "lost" pay streak in this part of the creek.

Chatanika Flats.—On lower Dome Creek, in the Chatanika Flats, the successful operation of a plant on the Niggerhead group and prospecting on the lower end of the group has defined a body of pay gravel at a depth of 180 feet which carries good values. Prospecting is also being done on the Recorder Association claim, which is just above the Niggerhead group and extends up Chatanika River, on the assumption that the pay comes from the river rather than from Dome Creek. Mining was being carried on at the mouth of Vault Creek on the Alabama Association claim, and about 4 miles below this point, near the mouth of Sargent Creek, gravel was being taken out from a 150-foot face which is 230 feet below the surface of the ground. The values are found on a false bedrock consisting of an impervious clay which is 89 feet above the real bedrock. It is thought by some of the miners that the developing and prospecting that have been done along the Chatanika Flats indicate a continuous pay streak from the mouth of Cleary down to Our Creek.

Little Eldorado Creek.—It is reported that a 20-ounce gold nugget was found in one of the clean-ups of a plant on the Idaho group of

Little Eldorado Creek. Considerable money was spent in prospecting on this creek last year without adequate results.

Homestake Creek.—The shallow gravels of the tributaries at the head of Chatanika River are suited to the method of hydraulicking in vogue in the Circle district. The small hydraulic plant installed on Homestake Creek this spring was in readiness for "piping in" early in July, and a good showing was made, considering the drawback that was experienced through low water. The water was diverted from Homestake Creek near its head and conducted by ditch and hydraulic pipe for about 3 miles along the right side of the creek to a point near the mouth, where mining operations were begun. The head attained is 160 feet and the depth of gravel to be worked averages about 8 feet.

CRIPPLE CREEK BASIN.

Ester Creek.—Mining operations are decidedly declining on Ester Creek, which in past years has yielded a percentage of the total production in the Fairbanks district second only to Cleary Creek. This is due principally to the fact that most of the richest portions of the creek have been worked out, but the lack of sufficient water for sluicing on Ready Bullion and upper Ester during the period of drought is also a contributing cause. The scheme of winter sluicing which was mentioned in last year's report was employed by three plants on Ready Bullion that were working in thawed ground. The plant on "No. 3 above first tier," which operated continuously during the winter, was visited by the writers early in the spring. A brief description of this plant will be given, as it affords an example of mining by the combination of thawed-ground and winter-sluicing methods. This is an unusual practice, for either condition is thought to considerably increase the cost of working ground. A 100-foot shaft to bedrock was joined by a system of tunnels, extending parallel and perpendicular to the course of the creek, which blocked out the gravel to be worked into 50-foot squares on the bedrock level. The supports for the small spruce pole shoring used for supporting the weight of the gravel consisted of uprights about 5 feet long and caps about 6 feet long hewed from spruce timber 10 to 12 inches in diameter. These were set 4 feet apart so that the poles, which were 8 feet long, could be driven ahead as the work on the face proceeded. It was not found practicable to pull this timbering, although the blocks farthest from the shaft were worked first and the ground was allowed to settle behind the working face. The gravel was conveyed from the face to the bucket hoist on cars of six wheelbarrows capacity, running on rails. A 3-inch pump kept the mine drained and by turning the exhaust into the sump hole warm water was furnished for sluicing. The exhaust from the steam hoist was conducted along the bottom of the sluice boxes by use of canvas cover and aided materially in keeping the temperature above the freezing point. The sluice water drained from the tailing pile into a stilling reservoir and was again warmed by the exhaust from the pump, which raised it to a flume. The water was led back to the sluice boxes through this flume and was there joined by more water from the drain pump in the mine to begin a new circuit. No difficulty was experienced in operating, even when the thermometer stood at 60° below zero. It is interesting to note that the cost of working ground in this manner was claimed by the operators to be about 75 cents a square foot on a basis of weekly running expenses, not, however, taking into account interest, depreciation, etc. Sixty men were employed and between 5,000 and 5,500 square feet of bedrock was worked out weekly.

Winter operations on Ester Creek proper consisted of blocking out ground for summer work and taking out dumps to be washed up in the spring. It is estimated that there were about 200 men employed on about 17 claims of Ester Creek and tributaries during the closed season. No data are available for estimating the summer work, but it is thought that it was not nearly so extensive. The largest plant of the creek, working on "No. 3 below" and employing about 60 men, was compelled to discontinue work during the later part of the season on account of the laborers demanding $6 a day instead of the customary wages of $5 a day.

Prospecting opposite "No. 6 below," 1,500 feet to the right of the present pay streak, brought to light some very rich coarse gold prospects which are similar to the gold found on the right side of "No. 2 below." As this gold is very unlike the finer values found in the creek claims, further prospecting is under way to determine whether there is another old channel, curving to the right, which carries this coarse gold.

St. Patrick, Emma, and Alder creeks.—Very little actual mining was done in 1910 on St. Patrick, Emma, and Alder creeks, which are small tributaries of Cripple Creek.

FISH CREEK BASIN.

Fairbanks Creek.—Fairbanks Creek, though not a large producer, has yielded a steadier annual output than any other creek in the district. Mining by both open-cut and drifting methods was carried on from "No. 10 above" to "No. 11 below." Six or seven open-cut plants were in operation, most of which employed bottomless scrapers for stripping the ground and steam hoists for carrying the gravel to the sluice boxes. On "No. 3 below" a 45-horsepower bottomless scraper, having a capacity of 2½ cubic yards, was in use. There were a number of small operators employing a windlass for taking out the pillars and walls of gravel that were left in ground previously worked by larger plants. The scarcity of water in July and August made it necessary for several of the plants to work alternately day and night, so that the total flow of the creek could be utilized by each plant. Winter sluicing, which has been successfully conducted during the last two years, will be employed again this winter by three of the operators. Prospecting on "No. 11 above" in former years had been confined chiefly to the left side of the claims, but in 1910 some very good values were obtained in holes sunk on the right side. Crosscuts were run and further prospecting carried on during the later part of the summer to determine the extent of the high-grade gravel, but it was not learned what success attended these efforts. Summer development and prospecting has also resulted in the location of a body of gravel carrying values on claims of lower Walnut Creek and on the adjoining left-limit bench claims opposite "Nos. 1 and 2 below" of Fairbanks Creek. It is estimated that about 135 men were employed on 20 claims in this drainage basin during both the winter and summer seasons.

In the past there have been several large-scale plans under consideration which involved the use of a dredge for working the ground on Fairbanks Creek, and options on claims have been taken with that end in view, but so far as known nothing definite has been done toward putting these plans into effect. A number of owners are securing patents to their claims which insure absolute title and will simplify their relations with a dredging company, if one is organized.

Fish Creek.—A decided increase in mining operations has taken place on Fish Creek during the last year, and developments this summer seem to indicate that it will remain on the productive list for some years to come. A number of operators on the upper part of the creek who took out winter dumps were very agreeably surprised when their clean-ups netted more than they were expecting. This was due largely to the presence of coarse gold, which had not been found to any great extent in prospecting. It is reported that a $43 nugget was found in the spring clean-up of "No. 5 above," and later in the season the operators on "No. 2 above" are said to have taken out a nugget valued at $84.25. Previous to this spring it was thought that Fish Creek would produce chiefly fine gold.

Mining was being done on almost every claim from "No. 10 above" to "No. 2 above" by both open-cut and drifting methods. "Nos. 2 and 3 above" yielded the best returns for the summer season. Below "No. 2 above" there was some prospecting done, without success, in trying to locate a pay streak between this claim and "No. 8 below," where one outfit, employing four men, was occupied in drifting in gravel carrying fine gold. About 35 men were employed on eight claims during the winter, and it is probable that about 50 men were employed during the open season.

CIRCLE DISTRICT.

GENERAL CONDITIONS.

The success of the small hydraulic plant on Eagle Creek and the fact that Mammoth Creek has been put on a productive basis through the satisfactory operation of the larger plant installed there during the summer of 1909 has given an added impetus toward hydraulicking in this district. The character and depth of gravel and the nature of the bedrock of portions of the stream carrying values are favorable to this method of mining, provided sufficient water can be had at an effective head. The gradient of the streams, however, is not sufficient for disposing of the tailings without some system of stacking. A giant is used for this purpose in connection with the two plants mentioned above, which necessarily calls for an additional supply of water. In this district there are four or five projects under consideration which entail the use of water under a head for their development, and it is hoped that two of these will be in operation before the close of the season in 1911.

The economy attained in moving gravel by the two plants now in operation during the extremely dry season of 1910 and at relatively high elevations lends encouragement to those who look forward to mining the low-grade gravels in the Birch Creek bars and along Preacher Creek with the considerable volume of water which would be available for that purpose. It should be borne in mind by those contemplating the installation of plants that this district embraces an area of low run-off, and accordingly the water supply available for each project should be carefully determined.

A renewed interest in locating new pay streaks has been brought about by the small strikes on Bottom Dollar and Frying Pan creeks, and if the summer operations on Buckley Bar of Birch Creek proper prove successful doubtless attention will be again directed to this field of endeavor.

The transportation facilities for summer traffic were not greatly improved this season on account of lack of funds. The only substantial improvement in the roads consisted of laying corduroy across the Albert Creek swamp, which separated the Government road, as completed in 1909, from the Central House. The dry weather, however, made it possible to haul larger loads over the unimproved trails from Central House to Deadwood and Miller House than for a number of years in the past.

The district as a whole suffered somewhat from scarcity of labor during the fore part of the season, owing chiefly to the false report that there was a great need for laborers in the Fairbanks district and that wages there had been advanced to $6 a day.

CROOKED CREEK BASIN.

Mastodon Creek.—A livelier scene of small-scale mining operations was presented during the summer by Mastodon Creek, from "No. 7 above" to its head, than by any other part of the district. Here the depth of gold-bearing gravels is such that the open-cut method of mining is better suited for extracting the values than winter drifting. It is estimated that 85 men were employed in this section of the creek on 12 claims through most of the summer season, though only 16 men were working on about six claims during the winter. Two of the largest operators, employing about 25 men each, made use of bottomless scrapers for removing the overburden and bringing the gravel to the boxes. On "No. 21 above" a water wheel furnished the power for hoisting the gravel into the sluice boxes.

The title to the claims on the lower part of the creek from "No. 2 below" to "No. 7 above" has been secured by a company which proposes to divert water from Mastodon and Independence creeks for working the claims with small hydraulic elevators. A considerable part of this ground has been worked over during the last 10 years, but on account of the costly methods employed only the richest portions have yielded profits. The lower-grade gravels left at intervals in the creek bed and along the sides of the claims should net good returns if economical means of handling the gravel are provided. The company landed a 300-ton outfit, consisting principally of hydraulic pipe, at Circle before the close of navigation, and if plans are fulfilled the plant will be in readiness for operating early in June, 1911. As the quantity of water is an important factor to be considered, it is thought that the use of pipe for conveying the water to the elevator pits will make it possible to begin sluicing earlier in the season and that thereby a greater percentage of the spring run-off may be utilized. Furthermore, the pipe can be used again in other localities under similar conditions. "No. 6 below," upon which six mén were employed, was the only claim that was worked on the lower part of the creek.

Mammoth Creek.—The largest hydraulic plant of the Yukon-Tanana region was in operation on Mammoth Creek. Here water was diverted from Bonanza and Porcupine creeks at an elevation of about 2,350 feet and conducted to the left bank of Mammoth Creek by a ditch 10.3 miles long. The lower part of the ditch below the Bonanza intake, 6.5 miles long, was constructed in 1908 and put into good working order in 1909. A portion of the Porcupine branch of the ditch was dug in 1909 and the ground along the remainder of the ditch line was stripped of moss to allow the underlying frozen muck to thaw. Much difficulty was experienced in completing this section of the ditch last summer on account of ground ice along the steep slopes near the Porcupine intake. Wherever the ditch line crossed these pockets of nearly clear ice, the ice was kept exposed to the open air and a drain provided to expedite thawing. This process of thawing quickly opened up a good-sized hole in the side of the hill, and when it was possible to provide a good foundation the space below the ditch was filled in with layers of moss and dirt. This ditch was built to a grade of 5.3 feet per mile with a width of 6.5 feet on the bottom. The usual form of construction, which consists of making the bottom of a ditch level, was not followed in building the upper ditch. The method adopted constitutes digging the side next to the hillside five-tenths deeper than the embankment side. When carrying water, a ditch with this cross section will have its greatest depth next to the hillside, and as the highest velocity of a stream or ditch is usually at the deepest section it is thought that the tendency of the water to cut the embankment will thus be decreased.

Operations on "No. 7 below" were carried on by the method of "piping in," a detailed description[1] of which has already been published. A head of 375 feet is available, but only 270 feet on bedrock was used. The completion of the Porcupine branch and the maintenance of the lower ditch kept 17 men busy during the summer and 14 men were employed at the mine. Low water proved to be the most serious drawback to the operations of the season. Data concerning the amount of water available at each intake may be found on page 200. Since a reservoir was not provided the method of sluicing intermittently, as practiced on Eagle, could not be employed on Mammoth. By reducing the size of the nozzle, however, it was found possible to work to an advantage during most of the low-water period, as only five days in July were lost through inadequate water supply. Frozen ground also offered considerable inconvenience, but doubtless the scheme adopted of stripping the gravel ahead of the pit a year in advance of operations will do much toward averting this difficulty.

Deadwood Creek.—Mining operations on Deadwood Creek during the winter of 1909 and summer of 1910, though handicapped on account of the low water, were about the same as in the previous two years. Here there seems to be no tendency toward adopting methods leading to a reduction in the cost of extracting the gold. The fact that most of the claims are worked by one to three men with pick, shovel, and hand windlass as the only labor-saving devices makes it evident that ground worked at a profit in this manner would pay well if more extensive equipment were provided. If the increased activity in hydraulicking in other parts of the district proves successful no doubt this method can be applied advantageously in working

[1] Ellsworth, C. E., Placer mining in the Yukon-Tanana region: Bull. U. S. Geol. Survey No. 442, 1909, p. 237.

the Deadwood deposits. The water supply available for this purpose above Switch Creek is stated on page 200. During part of the season good results were obtained from the operation of an automatic dam about a mile above Discovery claim. Considerable difficulty was experienced on the upper part of the creek with the "glacier," which formed on the claims during the winter to a depth of 15 feet in places and which did not disappear until late in July. Since there was very little water in Switch Creek after the spring thaw, operators were compelled to shut down work soon after the winter dumps had been sluiced. Information collected indicates that about 30 men were occupied in mining on 16 claims during the open season and that about 20 men worked 14 claims in the winter.

Independence Creek.—Mining on Independence Creek was carried on from "No. 5 below" to "No. 13 above" by 22 men working on six claims during the summer. Winter operations consisted of eight men drifting on six claims. Pick and shovel methods are used in working the deposits during both the open and closed seasons. It is reported that eventually the lower part of the creek will be hydraulicked by the company which has gained control of the lower portion of Mastodon Creek.

Miller Creek.—There were practically no mining operations on Miller Creek during the year. The ownership of all the claims from the mouth of the creek, "No. 7 below," to "No. 21 above" has come under the control of a company which proposes to build a ditch and work the ground with methods similar to those used on Eagle Creek. As the depth to bedrock is only 6 to 7 feet at the upper end of the creek and 12 to 14 feet on the lower end, little difficulty should be encountered in stacking the tailings. Owing to the meager water supply of Miller Creek (see p. 201) it will probably be necessary to provide a reservoir for storing the water so that it can be used intermittently during periods of drought, as is done on Eagle Creek. Ten men were employed during the later part of the summer stripping ground for a ditch, so that the large crew of men to be employed in the spring can carry the work on to completion. It is hoped that the plant will be ready to make use of the spring run-off in 1912.

NORTH FORK OF BIRCH CREEK BASIN.

Eagle Creek.—Hydraulicking on Eagle Creek was an experiment when first begun during the summer of 1908. The successful operation of the plant there during the last two seasons has shown conclusively that a small outfit and a small water supply can give good results when managed properly. It is estimated that ground carrying values as low as $1 a cubic yard can be worked to a profit with this method and under similar conditions—a fact which makes it evident that there are a number of deposits of gravel in the Circle district that would render good returns if this same means of exploitation could be employed.

The use of a small reservoir above the Mastodon Fork intake of the ditch made working on a small scale possible even during the excessively dry period in the middle of July, when the mean daily supply delivered by the ditch was probably less than 2 second-feet (80 miner's inches). The system used involved allowing the reservoir and ditch to fill and drawing on the storage thus supplied to operate the giants until both were emptied. It was only possible to work with about 500 miner's inches for two hours to the shift while the water was at its lowest stage. Seven men were employed to operate the plant during the summer.

Harrison Creek.—There were no operations on Harrison Creek proper during the last season, but it is reported that a hydraulicking project is being contemplated. Winter prospecting in 1909–10 on Bottom Dollar Creek and its tributaries, Half Dollar and Two Bit Gulch, resulted in locating some good prospects, and several small dumps were taken out which netted good returns when sluiced in the spring. It is understood, however, that the pay streak was found to be narrow and the gold contained in it irregularly distributed. Two men worked on the creek during the summer.

McLain Creek.—Two men were employed in operating an automatic dam on McLain Creek, which flows into Birch Creek just above Deadman Bar, but the work was hampered through lack of water. If a body of gravel of sufficient extent and of sufficient gold content can be located at this point to warrant the building of about 15 miles of ditch and to provide suitable hydraulic equipment, it is thought that an abundant water supply can be diverted from Clums Fork, which would give a working head at the mouth of McLain Creek of about 200 feet. A measurement of Clums Fork at the mouth on July 25, during a medium stage, gave a discharge of 118 second-feet (4,700 miner's inches).

Fryingpan Creek.—During the winter three prospectors located good values in a hole sunk to bedrock on the left side of Fryingpan Creek about one-half mile below the forks. The ground at this point is about 20 feet deep, comprising 15 feet of overburden and 4 or 5 feet of pay gravel. A small ditch was built and prospecting continued during the summer.

PREACHER CREEK BASIN.

The only mining done in the Preacher Creek drainage basin consisted of installing and operating an automatic dam on Bachelor Creek just below Costa Fork in the later part of the season. The scheme to work the Bachelor Creek gravels by the use of hydraulic lifts, which led to expending considerable money in partly constructing a ditch in 1909, has apparently been abandoned. It is reported that large bodies of low-grade gravel exist in the Preacher Creek valley below the mouth of Bachelor Creek which could be conveniently worked by some system of hydraulicking. A low-water measurement of 45 second-feet (1,800 miner's inches) above the mouth of Bachelor Creek seems to indicate that there is sufficient water for this purpose.

BEAVER CREEK BASIN.

Prospects were found in the upper tributaries of Beaver Creek which led to the staking of considerable ground long before the Fairbanks district was developed, but no actual mining operations were carried on in that vicinity. Desultory prospecting in later years seemed to indicate that the gold content of the gravel is very irregularly distributed and that it is not extensive enough to warrant any considerable outlay of capital.

During May, 1910, some good values were found, however, on Ophir Creek, a tributary to Nome Creek, which resulted in starting a small stampede about the middle of July. All of the ground in the Nome and Trail Creek drainage basins was staked, as well as that on several other creeks near by. Systematic prospecting followed in the wake of the stampede, and if reports are to be relied upon pay streaks have been located on Nome Creek above Ophir and on Ophir Creek near its mouth. Bedrock drains were being established on upper Nome Creek during the summer by an outfit which proposes to operate a bottomless steam scraper next season. The ground is all shallow, averaging about 15 feet deep, with 2 to 4 feet of pay gravel, so that open-cut methods will no doubt prove to be the cheapest means of recovering the gold. Ophir Creek, which flows into Nome Creek about 2 miles from its mouth, was the scene of the liveliest excitement during the stampede. On Discovery claim a 50-foot crosscut was run to determine the width of the pay streak, and it is stated that this was traced for a length of five claims before the close of the open season. The gravel carries coarse gold values at about \$17 an ounce, and it is reported to run from \$1.25 to \$1.75 a square foot. The largest nugget found was valued at \$4.30. Some very encouraging values were found on Trail Creek, which heads opposite Poker Creek, flows for about 15 miles in a northeasterly direction, and joins Beaver Creek about 6 miles below Nome Creek. Prospects were also found on several newly named creeks, such as Dominion Creek, Gold Mountain Creek, and Hoosier Creek, the locations of which were not learned by the writers.

There was much complaint registered against the laws which make it possible for one man, with the power of attorney from others, to stake association claims. It is said that 12 miles of creek was staked by one man in this manner.

HOT SPRINGS DISTRICT.

The value of the gold production in the Hot Springs district for 1910 is estimated to be approximately $325,000, which is the same as that estimated for 1909. The increased output from Sullivan and Cache creeks offsets the decrease from the Baker Creek mines.

It is understood that a large quantity of machinery has been shipped into the Patterson Creek basin, and the lack of capital, which has seriously retarded the proper development of the mines since the discovery of gold in this section in 1907, was not so marked during the last season as in previous years. It is reported that stream tin has been found in considerable quantities at nearly all the mines in this basin and that an investigation will be made relative to the possibility of saving that metal in connection with the recovery of the gold. It is believed, however, that the value of the presence of that metal lies in its indication that a ledge may exist, which, if located, might be worked at a profit. Sluicing in the basin opened May 10 on Tofty Gulch, where a prosperous season was reported. The overburden was groundsluiced off, and the auriferous gravel carried to the sluice boxes by a steam scraper. On Sullivan and Cache creeks new deposits of pay gravel are continually being located. Considerable difficulty has been caused by lack of sufficient sluicing water, and pumping has been resorted to on several claims in order to return the water to the head of the sluice after passing through. A few men were also mining on Quartz Creek during the summer.

On Thanksgiving and Pioneer creeks, where open-cut methods are used almost exclusively, a greater quantity of water is necessary for the successful operation of the mines than in those sections where deep-mining methods are practiced. The extreme drought, together with the losses due to carrying the water in ditches for several miles, caused the suspension of operations during a greater part of the season. On Eureka Creek claims "No. 7 above" to "No. 3 below" were worked by a Bagley bottomless scraper. The ground averaged about 12 feet deep and favorable results were reported, although some difficulty must have been experienced from the prevailing scarcity of water.

RAMPART DISTRICT.

The estimated value of the gold output from the Rampart district in 1910 was $43,000, about equally divided between winter and summer production. It was less than half the estimated output for 1909, and the decrease was undoubtedly due mainly to the fact that the richest pay streaks are about worked out, although a small decrease can be attributed to the closing down of the hydraulic plant on Hoosier Creek. It is estimated that 33 men were employed in mining on 18 claims during the winter of 1909–10 and 42 men on 15 claims in the summer of 1910. The chief development in the district during the past season was the introduction of a steam-shovel plant on Hunter Creek which was in operation near Discovery. Little Minook continues to be the chief producer and Hunter Creek comes second in output. Quail Creek takes third place, showing a larger production than for any year in the past, and if economical mining methods are introduced the creek promises to be one of the chief producers of the district. Some mining was also done on Little Minook Junior, Slate, Hoosier, and Big Minook creeks. It is reported that good prospects have been found on Hosiana Creek and in the fall of 1910 about 50 men were prospecting in the vicinity.

SALCHA-TENDERFOOT DISTRICT.

Tenderfoot Creek.—Renewed activity in mining operations on Tenderfoot Creek resulted from the location of good pay on bench claims opposite "Nos. 6 to 9 below." The appearance of the schist bedrock and the character of the wash indicate a higher channel which carries coarser gold than that found in the creek claims. Since the depth of the ground on this creek varies from 30 feet at "No. 1 below" to 180 feet at "No. 17 below" only drifting methods can be used for extracting the values. Small outfits were distributed rather irregularly along the creek from "No. 1 above" to "No. 14 below" and mining was being carried on during both the open and the closed season. The summer operations were greatly handicapped, however, through scarcity of water for sluicing. On an average between 25 and 30 men were employed on 10 claims throughout the year.

Banner Creek.—Very little mining was done on Banner Creek proper during the year, but considerable work was done on Democrat Creek, an upper tributary. The production of "Nos. 1 and 2 above" Democrat Creek represents a very large percentage of the total output of the creek. The depth of ground on these claims permits the use of open-cut methods. Two small outfits were also mining on Buckeye Creek.

Salcha River tributaries.—Actual mining operations in the upper Salcha basin were confined to No Grub and Caribou creeks. It is understood that very good returns resulted from the season's work in spite of the difficulties encountered in this section due to thawed ground and underground water. It is estimated that 20 men were employed in mining on about five claims. Seven men were occupied in prospecting on Twentymile and Butte creeks and about 10 men busied themselves in hunting pay gravel farther toward the head of Salcha River.

FORTYMILE DISTRICT.

GENERAL CONDITIONS.

Although no water-supply investigations have been carried on in the Fortymile district prior to 1910, it is believed that the stream flow for the summer reached an extremely low stage, and the decrease in the value of the gold output from $225,000 in 1909 to $200,000 in 1910 can be attributed almost entirely to the inadequate supply of water for mining. No new developments were introduced during 1910, and the mining methods used were practically the same as have been in vogue for several years. The possibilities of economically recovering the gold by means of dredges have been seriously studied, and since 1907 five different dredges have been installed on Fortymile River and its tributaries. The experience derived from their operations should be of incomparable value to those contemplating the introduction of such methods elsewhere in the Yukon-Tanana region, where conditions in a general way are very similar. Perhaps as a whole they have not proved to be a financial success, and sufficient information is not available to determine the reasons for the failures which have occurred. It is probable, however, that failures are in a large measure directly chargeable to lack of thorough prospecting on the part of the promoters to determine the gold content of the ground. The value of thorough prospecting by those vitally interested can not be too much emphasized, for it shows not only the value of the gold that can be obtained from the unit quantities of gravel to be mined but also the suitability of the ground for dredging. No hydraulic development of any magnitude has been instituted in this district, but it seems reasonable to predict that eventually such means will be employed to a considerable extent. It is hoped that the investigations relative to the water supply which are being carried on in the district will prove of value in considering the feasibility of the several projects and that failures due to a lack of sufficient water may be largely eliminated by such information. A summary of the stream-flow data gathered in this district during 1910 can be found on pages 202–209.

MINING OPERATIONS.

Walker Fork.—The dredge on Walker Fork near Poker Creek had an exceptionally prosperous season. Some trouble was encountered during the earlier part of the summer in frozen ground and steam points were used to thaw ahead of the dredge, but it is understood that after the middle of July no further difficulties were experienced in that respect. A gang of men was kept at work stripping the ground that will be worked another season, and it is expected that by so doing the ground will be thawed ready for the dredge. The dredge is steam driven and the fuel supply, which is wood, has become so depleted that it is now necessary to haul it several miles, making an excessive cost, which on some ground might prove so dear that operations would be conducted at a loss.

Considerable work was in progress on both Davis and Poker creeks and about six or seven men were working on each creek. The gold was recovered by groundsluicing and shoveling into sluice boxes. No winter work has been done on either creek, aside from propecting.

Two men were engaged in prospecting Walker Fork below Cherry Creek in order to determine the feasibility of dredging in that vicinity, but the results are not known. Some prospecting was also done on Cherry Creek.

Canyon and Squaw creeks.—On Canyon Creek about 3 miles below Squaw Gulch a steam scraper of one-half yard capacity, drawn by a 45-horsepower boiler connected with a double-drum hoist, was in operation during the later part of the season. It is claimed that 150 cubic yards could be handled per day of 10 hours. The ground averages about 7 feet in depth and is practically all gravel. The bedrock is slate and mica schist, and about 2 feet is moved in order to recover all the gold. A plowlike arrangement, operated by the same line of cables that is employed in hoisting the dirt to the sluice, is used to break up the bedrock so that it can be moved by the scraper. The plowing was done in the evening, and two or three men were able in a few hours to loosen all the bedrock that could be handled during the following day. Eight men were employed in connection with the plant. During the early part of the season a scraping plant of smaller capacity was in operation just below the mouth of Squaw Gulch.

On Squaw Gulch three or four outfits of one to three men each were mining by open-cut methods at times during the summer.

Wade Creek.—The production from Wade Creek in the summer of 1910 was greatly curtailed by a lack of water during most of the season. In the winter 18 claims were worked by 41 men, and during the summer 24 men were employed on 10 claims when the water supply was adequate. All the summer work was done by open-cut methods and was confined mostly to bench claims.

Chicken Creek and tributaries.—Although the lack of water for sluicing necessitated the suspension of operations on Chicken Creek during the greater part of the season, two outfits employing 6 men were drifting and 11 men were doing open-cut work on four claims for short periods throughout the season. Only one claim was worked during the winter and on this 10 men were employed.

The mining on Stonehouse Creek was about equally divided between winter and summer work. Ten different claims were worked by three men each. On Myers Fork seven men were mining on claims Nos. 1, 2, and 5 at different times of the year. During the summer open-cut methods were used.

On Lost Chicken Creek five or six men were engaged in mining for most of the year.

Ingle Creek.—Reports from Ingle Creek indicate that considerable work was in progress, and about five men were engaged in mining during most of the year. Four claims were worked by drifting in winter and open-cut methods in the summer. Some work was done also on Lilliwig Gulch, which is a small tributary of Ingle Creek.

Franklin and Napoleon creeks.—Franklin Creek, the oldest gold-producing tributary of Fortymile River, is still being mined each summer by groundsluicing and shoveling into boxes. Very little was accomplished during July and August because of a lack of water, although six men were on the creek in readiness for work when the supply would permit.

Work on Napoleon Creek was also brought to a standstill by a lack of water during the greater part of the season, although two men recovered some gold in the short time that a sluice head was available.

Other streams.—Pay gravel has been found on Fortyfive Pup, a tributary of Buckskin Creek, at claim No. 13, and considerable ground was worked by two men under the prevailing difficulties attending mining operations in a small drainage basin during a dry season.

Hutchinson Creek and its two tributaries, Confederate and Montana creeks, are known to carry pay gravel, but the extremely dry weather of the season of 1910 practically eliminated all operations involving the recovery of gold, although considerable dead work was accomplished. Two automatic dams were built. Five men were in the basin during the summer.

Fortymile bars.—Gravels with a high gold content are said to occur on a bench of Fortymile River near the mouth of Twin Creek, which is a tributary from the north about one-half mile below Steele Creek. During the summer of 1909 a ditch was built which diverts water from Twin Creek a short distance below the forks. It has a length of 9,000 feet, a bottom width of 2 feet, and a grade of 6.9 feet per mile. A pressure of 150 feet is obtained, and it is planned to hydraulic the bench gravels. No mining was accomplished during the season of 1910, owing to a lack of water.

A small dredge designed more especially for prospecting was in operation for a portion of the season on a bar of Fortymile River near the boundary, but the details of the operation are not known.

On Atwater Bar, at the mouth of Atwater Creek, four men were mining during a considerable portion of the year, and it is reported that satisfactory results were obtained.

Owing to the low stage of the river during the summer the conditions were extremely favorable for the few men who were washing the gravel by the use of rockers.

Troublesome Point, opposite the mouth of Franklin Creek, is still the scene of mining, but very little was accomplished during the summer, owing to the fact that the water supply is derived from a small gulch back of the mine which could furnish a sluice head of water only during a period of extended rains.

SEVENTYMILE DISTRICT.

It is estimated that the combined gold output from the Seventymile and Eagle districts for the year 1910 was approximately $10,000. In the Seventymile district about 20 men were engaged in mining, but during the winter very little was done aside from prospecting. Early in the spring considerable local excitement was caused by the finding of some coarse gold on Rock Creek near its head. The depth of the ground is about 50 feet, composed almost entirely of muck. As the gold is concentrated on bedrock high values to the pan were obtained, but the aggregate value of the gold content per square foot of bedrock was too small for the ground to be worked at a profit. Several large boilers were shipped to the creek and prospecting was continued throughout the summer, but no more encouraging prospects were found.

During the summer of 1909 a ditch which diverts water from Sonickson Creek was constructed, but it was not put into use until last season, when the water under pressure was used to remove the overburden from the river bar above the falls. The ditch is 6,000 feet long and has a bottom width of 3 feet and a grade of 4.6 feet per mile. A pressure of 150 feet is available. A Ruble elevator was constructed but did not prove adapted to the conditions. The overburden was therefore hydraulicked into the river and the pay gravel shoveled into sluice boxes. On Curtis Bar a small winter dump was taken out and some work was done during the summer. Two men were also mining on a bar just above the falls, on the north side of the river, for a short time during the later part of the season. On Crooked Creek claims "Nos. 2 and 3 above" were worked by 10 men most of the summer. The overburden was removed by water under a 40-foot pressure. The water was carried in a ditch 2,200 feet long. A small ditch was also constructed for use in working Discovery and adjoining claims.

Mining on Barney Creek was confined to the operation of the small hydraulic plant which has been in use for several years, and two men were employed in the performance of the work.

During the summer about a mile of ditch was built, which diverts water from Washington Creek [1] near its head and carries it over the divide for use on Pleasant Creek, which is the first tributary of Seventymile River from the north above Barney Creek. It is said

[1] Washington Creek heads in the divide north of Seventymile River near Barney Creek and is tributary to Yukon River about 15 miles above Charley River.

that the benches on the right bank of Pleasant Creek carry gravels containing sufficient gold to mine at a profit if an adequate water supply could be obtained, but it is very doubtful if the quantity available in Washington Creek, at the elevation necessary to carry it over the divide by gravity, will be found to be of much assistance.

One man was working on Nugget Creek and one on Broken Neck Creek during the summer when the water supply would permit.

Values are reported to have been found on Alder Creek. The auriferous gravels so far located lie in or near the creek channel, where the depth of the ground averages about 4 feet. Nuggets valued at $19, $8.50, and $7 and several $1 and $2 specimens were found. Plans were made to do considerable prospecting on Alder Creek during the winter of 1910–11.

Two men were engaged in mining on Flume Creek near the mouth throughout the season. A reservoir and an automatic dam were built on the left-limit bench of claim No. 1. The water was carried to the reservoir in a ditch which was constructed several years ago.

EAGLE DISTRICT.

In the Eagle district mining operations were confined to American Creek and its tributary, Discovery Fork. On American Creek two automatic dams were installed—one on claim "No. 8 above" and one on claim "No. 2 above." At the upper workings an average of four or five men were employed the entire season, and after the completion of the dam considerable ground was worked. At claim "No. 2 above" the work was confined almost entirely to the construction of the dam and waste ditch and the opening of ground in preparation for another season. Some mining was also done on two other claims during a part of the season. Two outfits of two men each were working by open-cut methods on Discovery Fork.

MINOR YUKON RIVER DISTRICTS.

On Woodchopper Creek during the winter of 1909–10 three claims were worked, on which 15 men were employed, and during the summer of 1910 six men were engaged in mining on two claims. The value of the gold output for the year is estimated at $19,000.

Fourth of July Creek gave a production of about $6,000. Four claims were worked in the winter by 11 men and in the summer 12 men were mining on five claims. Both drifting and open-cut methods were used. One automatic dam was in operation.

On Coal Creek an average of about 20 men were engaged in mining during the year. A hydraulic plant was operated under a pressure of 160 feet. The water was diverted from Boulder Creek, which is a small tributary of Coal Creek. It is reported that values have been located on Sams Creek and that about 16 men were either mining or prospecting along the stream.

Two men were mining by open-cut methods on Surprise Creek, which is a tributary of Washington Creek.

WATER SUPPLY OF THE YUKON-TANANA REGION, 1910.

By C. E. Ellsworth and G. L. Parker.

INTRODUCTION.

This report has been prepared to furnish for immediate use the essential results of the water-supply investigations in the Yukon-Tanana region during the season of 1910.

The work was begun in this region in 1907 and has been continued each succeeding year. The data collected in 1907 and 1908 [1] and their analyses have been published in detail. Those of 1909 [2] were presented in the progress report for that year in a form similar to the arrangement used in this paper.

The writers arrived at Fairbanks March 31, and until the later part of May the time was devoted to a study of winter run-off and mining conditions and to general preparations for the summer work. In the early part of June, after having commenced the investigations in the Circle district, C. E. Ellsworth proceeded to Eagle and began a study of the water supply in the Fortymile, Eagle, and Seventymile districts, where he continued work until the later part of September. G. L. Parker continued the work in the Fairbanks, Circle, and Salchaket districts during the remainder of the season and was assisted by T J. Shaw during July and August in the Little Chena River drainage basin.

On account of the large area to be covered, the slow means of transportation, and the needs and possibilities of the several districts, it was decided that the data would be of more value if the investigations in the Rampart and Hot Springs districts were discontinued and the remaining time devoted to a more thorough study of the conditions in the Fairbanks and Circle districts.

The writers desire to express their appreciation of the courtesies extended and aid given to the work by many residents of the region. Special acknowledgments for supplying gage readings are due to

[1] Covert, C. C., and Ellsworth, C. E., Water-supply investigations in the Yukon-Tanana region, Alaska, 1907-8: Water-Supply Paper U. S. Geol. Survey No. 228, 1909.

[2] Ellsworth, C. E., Water supply of the Yukon-Tanana region, 1909: Bull. U S. Geol. Survey No. 442, 1910, pp. 251-283.

Messrs. J. P. Carroll, Albert Carruthers, M. Danielson, J. T. Dickinson, August Fritch, Arthur Froelich, Mrs. A. Gustavason, Messrs. R. C. Hall, William Hugel, Alfred Johnson, J. F. Kelley, J. W. McCluskey, Jack McLin, Dan McPherson, Charles Martin, —— Michaels, Frank Miller, Frank Montgomery, Oscar Morrill, W. F. Munson, James Murphy, T. E. Phillips, C. A. Pihl, —— Powers, John Roberts, E. A. Robertson, Henry Siemer, A. F. Stowe, John B. Tait, Mrs. F. Warren, and Messrs. Robert Warren and John Williams.

MISCELLANEOUS MEASUREMENTS.

A number of miscellaneous measurements were made during the season of 1910 at points where it was impracticable to attempt to procure daily records.

A comparison of the run-off per square mile at the points where daily records were obtained shows a general trend of similarity, but the daily variations and in some cases the monthly departures from the general average are so great that extreme care should be used in making estimates from these measurements.

The season as a whole was characterized by considerable fluctuation in the stage of the streams, but most of the miscellaneous measurements were made during July and August, when the run-off was very low and the flow fairly uniform.

EXPLANATION OF DATA AND METHODS.

The methods of carrying on the work and collecting the data were essentially the same as those previously used for similar work[1] but were adapted to the special conditions found in Alaska.

In the consideration of industrial or mining enterprises which use the water of streams, it is necessary to know the total amount of water flowing in the stream, the daily distribution of the flow, and facts in regard to the conditions affecting the flow. Several terms are used—such as second-foot, miner's inch, and gallons per minute—to describe the quantity of water flowing in a stream, the one selected depending on the use to be made of the data.

"Second-foot" is in most general use for all classes of work, and from it the quantity expressed in other terms may be obtained. It is an abbreviation of cubic foot per second, and may be defined as the quantity of water flowing per second in a stream 1 foot wide and 1 foot deep at the rate of 1 foot per second. It should be noted that it is a *rate* of flow, and to obtain the actual quantity of water it is necessary to multiply it by the time.

"Second-feet per square mile" is the average number of cubic feet of water flowing per second from each square mile of area drained,

[1] See Water-Supply Papers U. S. Geol. Survey Nos. 94, 95, and 201.

on the assumption that the run-off is distributed uniformly, as regards both time and area.

"Run-off, depth in inches on drainage area," is the depth to which the drainage area would be covered if all the water flowing from it in a given period were conserved and uniformly distributed on the surface. It is used for comparing run-off with rainfall, which is expressed in depth in inches.

The "miner's inch," the unit used in connection with placer mining, also expresses a rate of flow and is applied to water flowing through an orifice of a given size with a given head. The head and size of the orifice used in different localities vary, thus making it a most indefinite and unsatisfactory unit. Owing to the confusion arising from its use it has been defined by law in several States. The California miner's inch is in most common use in the United States and was defined by an act approved March 23, 1901, as follows: "The standard miner's inch of water shall be equivalent or equal to 1½ cubic feet of water per minute, measured through any aperture or orifice." This miner's inch corresponds to the so-called "6-inch pressure," and is one-fortieth of a second-foot.

The determination of the quantity of water flowing past a certain section of a stream at a given time is termed a "discharge measurement." The quantity is the product of two factors—the mean velocity and the area of the cross section. The mean velocity is a function of surface slope, wetted perimeter, roughness of bed, and the channel conditions at, above, and below the gaging station. The area depends on the contour of the bed and the fluctuations of the surface. The two principal ways of measuring the velocity of a stream are by floats and current meters.

All measurements by the engineers of the Survey were made with the current meter, but as float measurements can readily be made by the prospector the method is described below.

The floats in common use are the surface, subsurface, and tube or rod floats. A corked bottle with a flag in the top and weighted at the bottom makes one of the most satisfactory surface floats, as it is affected but little by wind. In flood measurements good results can be obtained by observing the velocity of floating cakes of ice or débris. In all surface-float measurements the observed velocity must be multiplied by 0.85 to 0.90 to reduce it to the mean velocity. The subsurface and tube or rod floats are intended to give directly the mean velocity in the vertical. Tubes give excellent results when the channel conditions are good, as in canals.

In measuring velocity by a float, observation is made of the time taken by the float to pass over the "run"—a selected stretch of river or creek from 50 to 200 feet long. In each discharge measurement a large number of velocity determinations are made at different points across the stream, and from these observations the mean velocity for the whole section is determined.

The area used in float measurements is the mean of the areas at the two ends of the run and at several intermediate sections.

PRECIPITATION.

Precipitation records for 1910 show that the rainfall at Fairbanks was about 15 per cent below the average from 1906 to 1910; at Fort Gibbon it was about 6 per cent below the average from 1904 to 1910; and at Fort Egbert it was about 2 per cent above the average from 1903 to 1910. At Rampart a precipitation of only 5.32 inches was recorded, which is lower than that of any other year since the beginning of records at that station in 1905 and only about one-half the average for the last six years.

A comparison of the records of 1910 with those of 1909 shows that at Fairbanks and Fort Gibbon there was a small decrease in precipitation during the last year, whereas at Fort Egbert there was a considerable increase. At Rampart the decrease was nearly 50 per cent from the precipitation of 1909.

Although there is a wide difference from month to month and from year to year in the rainfall at the several stations in the Yukon-Tanana region, the mean yearly precipitation at each station for the period covered by the records is uniformly close to the average of the means of all the stations. In other words, the records show no uniform difference in precipitation throughout this area.

The following table gives the monthly precipitation at all points in the Yukon-Tanana region where records have been kept subsequent to 1903. Such scattered records as were kept previous to 1903 have been compiled by Abbe.[1]

Monthly precipitation, in inches, at stations in Yukon-Tanana region, 1903–1910.

[Rainfall or melted snow is given in the first line; snowfall in the second line.]

Station.	Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Central	1906	0.56	0.06	0.05	0.47	0.86	4.91	4.82	1.85	0.52	0.70	0.80	0.35	15.95
		6.1	1.0	1.4	4.7	2.0	......	......	......	......	7.0	8.0	4.0	34.2
Do	1907	1.04	.42	2.57	.93	.57	2.21	1.40	......	......	......	......	......	......
		10.0	4.0	4.0	8.0	1.5	......	......	......	......	......	......	......	......
Circle	1906	......	......	......	......	......	......	......	......	......	......	......	.75	......
		......	......	......	......	......	......	......	......	......	......	......	9.5	......
Do	1907	1.02	.57	.28	.15	.29	......	1.36	2.79	1.73	......	......	.63	......
		8.5	7.8	3.25	......	......	......	......	......	......	......	......	8.2	......
Do	1908	1.23	.25	.76	1.45	.29	.20	.87	1.08	2.21	.40	.75	1.11	10.60
		9.2	2.5	6.8	8.0	......	......	......	......	......	3.0	8.5	11.2	51.2
Do	1909	.44	.47	.17	.75	.60	2.24	3.25	1.02	......	......	......	......	......
		4.5	5.2	1.0	3.0	......	......	......	......	......	......	......	......	......
Charity Creek	1908	......	......	......	.11	.27	1.33	2.80	2.33	2.28	.20	......	......	......
		......	......	......	......	......	......	......	......	......	3.0	......	......	......
Cleary	1907	......	......	......	......	......	.84	2.55	2.88	3.82	......	......	......	......
Eagle Creek	1908	......	......	......	......	......	......	......	2.99	......	......	......	......	......
Fairbanks	1904	......	......	......	......	......	......	......	......	......	......	1.10	2.00	......
Do	1905	.92	.50	.05	.20	......	......	......	2.63	.86	......	1.20	.60	......
		9.1	5.0	.5	2.0	......	......	......	......	......	......	12.0	5.1	......

[1] Abbe, Cleveland, jr., Prof. Paper U. S. Geol. Survey No. 45, 1906, pp. 189–200.

Monthly precipitation, in inches, at stations in Yukon-Tanana region, 1903–1910—Con.

Station.	Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Fairbanks	1906	1.75	0.37	0.33	0.10	0.36	1.05	2.82	1.50	0.25	0.30	0.65	1.15	10.63
		17.5	3.7	3.3	1.0	......	......	......	......	......	.6	6.5	11.5	44.1
Do........	1907	3.30	.86	2.42	.03	.35	1.47	1.51	1.81	3.58	2.44	.35	.59	18.71
		33.0	8.6	24.2	.3	......	......	......	......	......	24.4	3.5	5.9	99.9
Do........	1908	.42	.21	1.10	.11	.52	.96	.73	.71	1.57	.47	.51	.65	7.96
		4.2	2.1	11.0	.8	......	......	......	......	......	......	......	8.1	26.2
Do........	1909	.90	.08	.05	.66	.38	1.64	1.90	1.73	.39	.80	.52	.80	9.85
Do........	1910	.70	.14	.02	.36	.39	2.16	.46	1.69	1.91	.66	.50	.76	9.75
Faith Creek...	1907	......	......	......	......	......	......	1.87	3.00	2.97	......	......	......	......
Fort Egbert...	1903	.58	.81	.54	.12	1.38	.57	2.40	.97	2.97	......	......	......	......
Do........	1905	......	......	......	......	.33	1.95	1.52	2.72	3.38	2.96	.93	.68	......
Do........	1906	......	.14	2.19	.00	.54	.51	2.54	1.28	.01	1.71	.51	.07	......
		......	1.0	11.0	......	......	......	......	......	......	.46	8.5	1.0	......
Do........	1907	1.45	.21	0	.25	.40	1.89	1.48	1.98	1.45	1.12	.40	.31	10.94
		2.0	2.0	0	.15	.55	......	......	......	......	13.0	4.0	......	......
Do........	1908	.12	.25	.75	.10	1.02	2.16	2.47	1.02	1.48	.18	.82	1.09	11.46
		3.0	2.5	7.5	1.0	......	......	......	......	......	6.0	7.0	11.0	38.0
Do........	1909	.16	.07	.11	.34	.28	2.35	1.77	.95	.88	.81	.30	......	......
		2.0	1.0	1.0	2.0	......	......	......	......	6.1	11.7	3.0	......	......
Do........	1910	.83	.01	.53	.25	.28	1.05	2.28	2.63	2.98	.69	.25	.30	12.08
Fort Gibbon..	1903	.37	.73	1.14	.23	.16	.38	1.76	......	.48	.22	.33	Tr.	......
Do........	1904	.08	.55	.35	.09	.22	.33	1.95	3.80	.35	.39	.07	.70	8.88
Do........	1905	.37	.47	Tr.	.32	.84	1.50	4.90	3.02	.59	.50	1.10	.18	13.79
Do........	1906	.65	.20	.30	Tr.	1.00	......	......	......	......	[a].50	.99	.27	......
		6.0	2.0	3.0	......	......	......	......	......	......	[a]5.0	9.9	2.7	......
Do........	1907	1.26	......	.53	0	.30	......	2.58	2 31	2.32	1.22	.03	.31	......
		12.6	......	5.0	0	......	......	......	......	4.0	12.0	1.5	......	......
Do........	1908	.23	.26	.90	0	1.16	......	.96	1.13	1.60	.45	.08	.60	......
		4.0	6.0	17.0	0	......	......	......	......	2.25	6.0	......	6.5	......
Do........	1909	.05	.10	.37	.39	1.51	.77	1.49	2.27	.90	.49	.46	.80	9.60
		.5	.5	......	2.2	......	......	......	......	......	4.8	4.6	8.0	20.6
Do........	1910	1.23	.08	.60	.28	.69	.57	1.79	2.26	.74	.38	......	.59	......
Hot Springs...	1909	......	......	......	......	......	......	1.76	3.19	.25	.44	1.10	2.26	......
		......	......	......	......	......	......	......	......	......	4.4	11.0	22.6	......
Do........	1910	1.64	.03	.60	.20	.34	.76	[b]2.16	......	1.32	......	......	......	......
		16.4	.3	6.0	2.0	3.4	......	......	......	......	......	......	......	......
Kechumstuk..	1904	......	......	......	......	1.80	.83	2.23	.94	.64	.30	.03	.23	......
Do........	1905	.90	.10	.05	.40	.20	1.58	.40	1.48	2.16	1.18	.36	.20	9.01
Do........	1906	.36	.05	.06	.27	1.69	1.61	3.25	2.51	.51	.31	.20	.20	11.11
		4.0	.5	1.0	5.0	......	......	......	......	......	4.3	.5	3.0	18.3
Do........	1907	.12	.20	.27	Tr.	1.30	2.03	1.60	2.14	.49	.72	.40	......	......
		2.0	3.0	4.0	......	12.0	......	......	......	2.0	9.0	4.0	......	......
Do........	1908	0	0	.41	.40	1.78	1.77	2.30	2.22	1.35	......	.90	.20	......
		0	0	5.0	4.0	......	......	......	......	......	......	9.0	2.0	......
Do........	1909	0	.30	.10	.20	0	3.66	3.39	......	......	......	......	......	......
		0	.5	1.0	......	0	......	......	......	......	......	......	......	......
Miller House..	1909	......	......	......	......	......	......	2.98	1.26	.60	.93	.30	.30	......
		......	......	......	......	......	......	......	......	4.0	8.0	3.0	3.0	......
Do........	1910	......	......	......	.20	......	1.94	2.37	.30	1.03	......	......	......	......
North Fork...	1905	......	......	......	......	......	......	......	1.91	1.85	......	.50	.20	......
Do........	1906	.70	.50	.10	.80	1.98	2.74	2.69	1.01	.72	.42	.55	.38	12.59
		7.0	5.0	1.0	8.0	......	......	......	......	......	3.2	4.5	4.5	33.2
Do........	1907	.69	.28	.27	Tr.	1.34	1.92	1.57	3.19	2.0	1.40	.20	......	......
		15.5	3.0	3.0	......	4.0	......	......	......	5.0	12.0	2.0	......	......
Do........	1908	.50	......	......	......	......	......	......	......	......	......	......	......	......
		5.0	Tr.	......	......	......	......	......	......	......	......	......	......	......
Poker Creek...	1907	......	......	......	......	......	......	......	1.40	3.70	1.70	.25	1.09	......
		......	......	......	......	......	......	......	......	......	24.0	3.3	6.8	......
Do........	1908	......	1.32	......	.42	.58	1.80	2.02	.99	2.45	.75	.35	.61	......
		......	10.5	......	5.0	......	......	......	......	4.5	6.9	4.4	12.6	......
Do........	1909	.68	.09	.03	.42	1.11	1.22	2.01	2.01	......	......	......	......	......
		8.8	2.0	.5	8.0	2.5	......	......	......	......	......	......	......	......
Rampart......	1905	......	......	......	......	......	1.33	1.99	2.19	1.70	1.20	1.43	.33	......
Do........	1906	.63	.08	.17	.04	.40	.15	1.86	2.40	.59	.61	.95	.33	8.21
		7.2	2.0	1.8	.5	......	......	......	......	......	......	10.2	3.5	25.2
Do........	1907	1.17	.44	1.17	.02	.44	1.64	2.29	3.38	2.52	.65	.55	1.26	15.53
		12.0	4.5	12.8	2.5	......	......	......	......	......	......	6.3	......	......
Do........	1908	1.08	.52	.81	.58	.82	1.38	1.13	.46	1.56	.39	.73	1.14	10.60
		11.5	6.9	8.1	......	......	......	......	......	......	5.1	3.6	16.8	52.0
Do........	1909	.09	.10	.37	.51	1.04	.85	2.01	1.41	.36	1.14	.35	1.99	10.22
		1.4	1.2	6.2	5.6	......	......	......	......	1.5	14.4	3.6	20.2	54.1
Do........	1910	.84	.08	.36	.07	.20	.98	.71	.62	.43	.45	.26	.32	5.32
		11.1	.8	4.7	1.0	......	......	......	......	......	6.0	3.5	5.0	32.1
Summit road house.......	1907	......	......	......	......	......	......	2.71	3.27	[c]3.33	......	......	......	......
Tanana Crossing.........	1904	......	......	......	......	.76	......	.78	.89	1.06	.15	.10	.90	......
Do........	1905	.24	.08	.18	.00	.14	......	.37	2.95	......	1.40	.60	......	......
Do........	1906	.30	.00	Tr.	......	......	......	......	......	......	......	......	......	......

[a] Oct. 7 to 31. [b] July 16 to 31. [c] Sept. 1 to 22.

Precipitation records for June to September, inclusive, at several points in the Yukon-Tanana region may be summarized as follows:

Summary of summer precipitation in Yukon-Tanana region.

Station.	Maximum.		Minimum.		Mean (inches).	Duration of records.	Precipitation for 1910 (inches).
	Inches.	Year.	Inches.	Year.			
Circle	7.64	1907	4.36	1908	6.38	1907–1909	....
Fairbanks	8.37	1907	3.97	1908	5.97	1906–1910	6.22
Fort Egbert	9.57	1905	5.95	1909	7.09	1903, 1905–1910	8.94
Fort Gibbon	10.01	1905	4.98	1908	6.59	1903–1905, 1907–1910	5.36
Kechumstuk	7.88	1906	4.64	1904	6.41	1904–1908	....
Rampart	9.83	1907	2.74	1910	5.66	1905–1910	2.74
Mean	....	....	....	....	6.35	....	5.82

The uniformity of precipitation throughout the Yukon-Tanana region, as already noted, for yearly periods is also noticeable, though to a less extent, for the summer months. In the above table Fort Egbert has the highest average precipitation from June to September and is 12 per cent above the mean for all of the stations; Rampart has the lowest average precipitation and is 11 per cent below the mean for all the stations.

The table also shows that a total precipitation as high as 10.01 inches and as low as 2.74 inches has occurred during the mining season and it leads to the conclusion that the general scarcity of water for mining uses during 1910 throughout the Yukon-Tanana region (with the exception of the Rampart district) was not due to an unusually small amount of rainfall in the aggregate but rather to its distribution with respect to time and area. A study of the run-off from adjoining drainage basins during the last four years indicates that a wide difference in stream flow may be expected even though geologic and topographic conditions are apparently very similar. In order to arrive at any definite conclusions regarding areal distribution of the rainfall by a comparison of simultaneous records, it would be necessary to have a greater number of rain gages more systematically located. Such comparisons as can be made with the existing data, however, confirm the general opinion that the precipitation is distributed rather unevenly. This condition is often noticeable in the summer, when local showers visit one portion of the drainage basin and do not reach another portion.

HYDRAULIC DEVELOPMENT.

Because of many unfavorable factors, mining by the use of water under pressure has so far played a very small part in the recovery of placer gold in the Yukon-Tanana region. The relatively high elevations at which most of the mines are located and the uniformity in elevation of the sources of the streams make it extremely difficult to obtain a sufficient supply of water at an elevation that will give a working head at the mines. The low stream gradients which prevail in the interior make necessary some means of elevating the gravels, which in turn involves the use of larger quantities of water under a higher head than would be necessary if the slope of the bedrock underlying the gravels was equal to or greater than that required for the sluice boxes.

Notwithstanding the many difficulties which must be overcome in order to successfully utilize such means of extracting the gold, several small plants have already been installed and larger ones are under consideration.

The developments in the several districts during the season of 1910 are described in another section of this volume. (See pp. 153–172.)

WATER POWER.

The following tables have been prepared in order to summarize briefly the records of stream flow that have been gathered on streams in the Yukon-Tanana region which offer any possibility for water-power development.

In comparing the columns showing days of deficient discharge for several years on any stream, allowance should be made for the difference in the length of periods and also for the part of the season covered by the records. Ordinarily the longer the period the greater will be the number of days of deficient discharge for any given number of horsepower and the less favorable will be the comparison with some other year in which the records extend over a shorter length of time. Also the days of deficient discharge will be a greater percentage of the total number of days if the observations include only the low-water months.

The following tables give the horsepower (80 per cent efficiency) per foot of fall that may be developed at different rates of discharge and show the number of days on which the discharge and the corresponding horsepower were respectively less than the amounts given in the columns for "discharge" and "horsepower."

Estimated discharge and horsepower table for Chatanika River, Little Chena River, and Washington Creek for 1907–1910.

Discharge in second-feet.	Horsepower (80 per cent efficiency) per foot fall.	Days of deficient discharge.										
		Chatanika River below Faith Creek.			Chatanika River below Poker Creek.				Little Chena River and tributaries.[a]			Washington Creek below Aggie Creek.
		June 21 to Sept. 30, 1907.	July 13 to Sept. 30, 1908.	May 25 to Sept. 25, 1910.	June 20 to Oct. 14, 1907.	May 16 to Oct. 21, 1908.	May 9 to Oct. 5, 1909.	May 17 to Oct. 29, 1910.	July 22 to Sept. 10, 1907.	May 1 to Aug. 27, 1908.	July 1 to Aug. 31, 1910.	May 5 to Sept. 4, 1908.
22	2	......	......	......	......	......	......	......	......	......	......	0
28	2.5	......	......	......	......	......	......	......	......	......	......	3
33	3	0	......	......	......	......	......	......	......	......	0	30
44	4	13	......	0	......	......	......	......	......	......	18	51
55	5	16	......	14	......	......	......	......	......	0	35	61
66	6	29	......	29	......	......	......	......	0	26	40	66
77	7	39	0	34	......	......	......	......	3	31	42	68
88	8	47	2	37	......	......	0	0	7	36	44	72
99	9	52	4	39	......	......	2	2	13	44	45	75
110	10	56	19	45	......	......	5	3	15	48	46	76
132	12	69	35	47	......	......	17	22	23	55	50	....
154	14	73	57	54	0	......	26	40	35	58	......	....
176	16	77	58	64	5	0	27	49	42	60	......	....
198	18	78	65	69	17	5	39	55	45	63	......	....
220	20	82	66	79	27	27	46	60	48	67	......	....

[a] The discharge of Little Chena River and tributaries includes the discharge of Little Chena River above Sorrels Creek, Elliott Creek, Sorrels Creek at mouth, and Fish Creek above Fairbanks Creek.

Estimated discharge and horsepower table for Fortymile and Seventymile rivers for 1910.

Discharge in second-feet.	Horsepower (80 per cent efficiency) per foot fall.	Days of deficient discharge.		Discharge in second-feet.	Horsepower (80 per cent efficiency) per foot fall.	Days of deficient discharge.	
		Fortymile River at "kink," July 9 to Sept. 23, 1910.	Seventymile River at falls, June 16 to Sept. 30, 1910.			Fortymile River at "kink," July 9 to Sept. 23, 1910.	Seventymile River at falls, June 16 to Sept. 30, 1910.
198	18	....	0	275	25	2	18
209	19	....	3	286	26	3	22
220	20	....	4	297	27	7	26
231	21	....	10	308	28	13	31
242	22	....	10	330	30	15	33
253	23	0	11	385	35	20	49
264	24	2	16	440	40	30	57

WINTER RUN-OFF.

Measurements were made during April, 1910, to determine the winter flow of several streams in the Yukon-Tanana region. They were made by chopping holes through ice varying in thickness from 2 to 3½ feet, sounding, and measuring the velocity at each section by a current meter. The results are given in the following table:

Winter discharge measurements in Yukon-Tanana region in 1910.

Date.	Stream.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-feet.*	*Sec.-feet.*
Apr. 6	Tanana River 3 miles below Chena	[a] 24,000	4,450	0.185
Apr. 8	Chatanika River below Poker Creek	456	1.91	.0042
Apr. 17	Salcha River at mouth	2,170	64.5	.0297

[a] This area was obtained from the topographic map of Alaska, scale 1:2,500,000, and is therefore only approximate.

It is reasonable to suppose that the discharge of streams in this section during April represents the minimum flow for the year if it is assumed that the supply is furnished by springs in the stream bed and underground drainage, which is no doubt the case.

The results obtained indicate that no general relation between the winter and summer flow can be deduced. Such a relation could hardly be expected, as the surface drainage is the principal factor regulating the summer flow, and this element is entirely lacking in the winter season, when all of the surface water is stored in the form of ice and snow.

It is interesting to note that the discharge per square mile of the streams measured is greater for large areas than for small, a relation which is ordinarily reversed during the summer months. There are not enough data at hand, however, to warrant the supposition that this relation exists generally.

FAIRBANKS DISTRICT.

DESCRIPTION.

The area known as the Fairbanks district extends about 60 miles to the north of Fairbanks and is from 40 to 50 miles wide. The greater part of the region lies in the lower Tanana basin, but a portion to the northwest drains directly to the Yukon. Generally speaking, the district embraces three divisions—a low, broad alluvial plain, a moderately high dissected plateau, and a mountain mass.

The low, broad plain forms the bottom lands of the lower Tanana Valley, which in this section is divided into several parts by the Tanana and its sloughlike channels. The main slough starts near the mouth of Salcha River, about 30 miles above Fairbanks, and diverts a portion of the Tanana waters. Its course is northward along the foothills of the plateau, and it receives Chena River about 9 miles above Fairbanks. The plain is swampy and is well covered with timber along the banks of the streams. In the vicinity of Fairbanks it has a general elevation of about 500 feet above sea level.

The plateau is drained by streams tributary to Tanana River which flow through rather broad, unsymmetrical valleys, chiefly extending in a northeast-southwest direction. Their bottom lands range in elevation from 500 to over 2,000 feet above sea level, and the dividing ridges are in general 1,000 to 3,000 feet above the stream beds. That portion of the plateau discussed in this report is drained principally by Little Chena and Chatanika rivers. The upper region of these drainage basins is crosscut by a zigzag range, which separates the Yukon from the Tanana drainage.

The mountain mass north of this plateau forms what might be termed the apex of the divide between the Tanana and the Yukon drainage basins; its highest points reach altitudes 4,000 to 5,000 feet above sea level and its corrugated slopes are drained principally by tributaries to Yukon River.

All drainage areas tributary to the Tanana are similar in character. The streams have little slope except near their source and flow over wide gravelly beds in shifting and tortuous courses, keeping to one side of the valley. Most of the channels have rather steep banks that form approaches to broad, level bottom lands which extend 1,000 to 4,000 feet or more before they meet the abrupt slopes of the dividing ridges. The drainage basins are 4 to 15 miles wide and are cut up by small tributary streams that flow through deep and narrow ravines.

A large portion of the area is covered with a thick turf, known as tundra, which is wet, spongy, and mossy and ranges in thickness from 6 inches to 2 feet. In some localities this is meadow-like, producing a rank growth of grass and a variety of beautiful wild flowers. Ground ice is found beneath this tundra in many places, particularly on the northern slopes, where the scanty soil supports little timber or other vegetation. The soil of the southern slopes is, for the most part, clay, underlain by a mica schist which affords suitable ground for ditch construction. When stripped of its mossy covering and exposed to the sun it thaws rapidly, so that the plow and scraper can be used to advantage.

Above altitudes of 2,000 to 2,200 feet practically the only vegetation is a scrubby, bushy growth which attains a height of 2 to 4 feet. In general the country below this altitude is timbered by spruce and birch, with scattered patches of tamarack and willow along the banks of the smaller streams. The timber increases in density and size toward the river bottoms, where the prevailing growth is spruce, much of which attains a diameter of 18 to 24 inches.

The Fairbanks mining district lies between Little Chena and Chatanika rivers. It embraces an area of about 500 square miles and extends 30 miles north of Fairbanks, which is situated on Chena Slough nearly 12 miles above its confluence with the Tanana. Most of the producing creeks rise in a high rocky ridge, of which Pedro Dome, with an elevation of about 2,500 feet, is the center. At least half of the mines are located at an elevation of over 800 feet, and 25 per cent are over 1,000 feet above sea level.

GAGING STATIONS AND MEASURING POINTS.

The following list gives the locations at which gaging stations were maintained or discharge measurements made in 1910, in the Fairbanks district:

Gaging stations and measuring points in Fairbanks district, 1910.

- Tanana River drainage basin:
  - Chena River drainage basin:
    - Chena River above Little Chena River.
    - Little Chena River above Sorrels Creek.
    - Little Chena River below Fish Creek.
    - Elliott Creek above mouth.
    - Elliott Creek at mouth.
    - Sorrels Creek at mouth.
    - Fish Creek below Solo Creek.
    - Fish Creek at mouth.
    - Solo Creek at mouth.
    - Bear Creek at mouth.
    - Fairbanks Creek at mouth.
    - Miller Creek above Heim Creek.
    - Miller Creek at mouth.
    - Heim Creek at mouth.
  - Chatanika River drainage basin:
    - Chatanika River below Faith Creek.
    - Chatanika River below Poker Creek.
    - McManus Creek at mouth.
    - Smith Creek above Pool Creek.
    - Pool Creek at mouth.
    - Charity Creek above Homestake Creek.
    - Homestake Creek at mouth.
    - Deep Creek at mouth.
    - Orphan Boy Creek at mouth.
    - First tributary below Sourdough Creek from right side at mouth.
    - Cripple Creek at mouth.
    - Cassiar Creek at mouth.
    - Flat Creek below Third Pup.
    - Flat Creek below First Pup.
    - Juniper Creek at mouth.
    - Kokomo Creek above Rusty Gold Creek.
    - Poker Creek at mouth.
    - Poker Creek ditch near outlet.
  - Goldstream Creek drainage basin:
    - Gilmore Creek near mouth.
    - Pedro Creek near mouth.
    - Fox Creek near mouth.

CHENA RIVER DRAINAGE BASIN.

Chena River drains the area lying between Chatanika River on the north, Birch Creek on the east, and Salcha River on the south. It has a length of about 100 miles and flows slightly south of west to the lowlands of the Tanana Valley, where it empties its waters into Chena Slough. The principal tributaries are the West Fork and Little Chena River from the north and the South Fork from the south.

Little Chena River and its tributaries Sorrels and Fish creeks drain the southern slope of the divide between Chatanika and Chena rivers from the headwaters of Smith and Flat creeks to Pedro Dome, a distance of about 25 miles. The drainage basin is irregular in shape and crossed by a network of small, ramifying streams with precipitous slopes in their upper courses. The upper portion of the main stream is also steep, having a fall of 100 to 150 feet to the mile, but this slope decreases rather abruptly to about 18 feet to the mile in the vicinity of Elliott and Fish creeks.

Above Fish Creek the Little Chena flows through a rather broad, unsymmetrical valley, but below that stream it takes the center of a deep, rather narrow channel for about 10 miles, to Anaconda Creek, an important tributary which enters from the left. Below this point the valley gradually widens again until the stream reaches the lowlands tributary to Chena River, with which it unites 6 or 8 miles above the confluence of Chena Slough.

Monthly discharge of streams in Little Chena River drainage basin for 1907–1910.

Little Chena River above Sorrels Creek.

[Drainage area, 79 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1907.					
July 22–31	80	42	49.3	0.625	0.23
August	157	53	85.4	1.08	1.24
Sept. 1–10	95	66	86.2	1.09	.40
The period, 51 days	157	42	78.4	.993	1.87
1908.					
May 20–31	405	210	296	3.75	1.67
June	223	65	142	1.80	2.01
July	65	33	43.2	.547	.63
Aug. 1–26	79	28	41.1	.520	.49
The period, 99 days	405	28	103	1.30	4.80
1910.					
July	166	22	37.0	.468	.54
August	350	22	74.5	.943	1.09
The period, 62 days	350	22	55.8	.706	1.63

Monthly discharge of streams in Little Chena River drainage basin for 1907–1910—Con.

Little Chena River below Fish Creek.

[Drainage area, 228 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1908.					
May	1,670	265	832	3.65	4.21
June	651	161	284	1.25	1.40
July	161	64	94.9	.416	.48
Aug. 1-27	122	59	79.2	.347	.35
The period, 119 days	1,670	59	332	1.46	6.44
1910.					
July	232	38	67.3	.295	.34
August	460	36	109	.478	.55
The period, 62 days	460	36	88.2	.386	.89

Elliott Creek above mouth.

[Drainage area, 13.8 square miles.]

1907.					
July 22-31	9.0	2.5	5.94	0.430	0.16
August	23	5.8	11.0	.797	.92
Sept. 1-10	12.3	9.0	10.1	.724	.27
The period, 51 days	23	2.5	9.82	.711	1.35
1908.					
May 20-31	216	11	67.8	4.91	2.19
June	32	8.6	14.8	1.07	1.19
July	7.5	4.5	5.22	.378	.44
Aug. 1-26	4.6	4.4	4.48	.324	.31
The period, 99 days	216	4.4	15.5	1.12	4.13
1910.					
July	10.6	2.3	3.50	.254	.29
August	15.1	2.3	5.60	.405	.47
The period, 62 days	15.1	2.3	4.55	.330	.76

Sorrels Creek near mouth.

[Drainage area, 21 square miles.]

1907.					
July 22-31	14.7	6.0	10.5	0.500	0.19
August	32.1	10.3	18.2	.867	1.00
Sept. 1-10	19	14.7	16.0	.762	.28
The period, 51 days	32.1	6.0	16.3	.777	1.47
1908.					
May 20-31	131	36	73.0	3.48	1.55
June	72	27	42.8	2.04	2.28
July	38	11	19.9	.948	1.09
Aug. 1-26	18	10	12.5	.595	.58
The period, 99 days	131	10	31.3	1.49	5.50
1910.					
July	46	3.6	7.53	.359	.41
August	36	3.6	12.2	.581	.67
The period, 62 days	46	3.6	9.86	.470	1.08

Daily discharge, in second-feet, of Chena and Little Chena rivers and Elliott Creek for 1910.[a]

Day.	Chena River above Little Chena River (drainage area, 1,440 square miles).						Little Chena River above Elliott Creek (drainage area, 79 square miles).		Little Chena River below Fish Creek (drainage area, 228 square miles).		Elliott Creek above mouth (drainage area, 13.8 square miles).	
	May.	June.	July.	Aug.	Sept.	Oct.	July.	Aug.	July.	Aug.	July.	Aug.
1	......	1,550	1,130	1,190	1,760	1,390	27	47	75	80	3.0	3.9
2	......	1,870	1,200	1,470	1,620	1,350	27	37	70	67	3.0	3.6
3	......	1,720	1,150	1,390	1,540	1,310	27	34	65	58	3.0	3.4
4	......	1,400	971	1,180	1,660	1,130	27	32	60	56	2.9	3.1
5	......	1,370	860	1,000	1,880	1,150	27	31	58	51	2.9	3.0
6	......	1,330	811	925	2,340	1,120	27	28	56	48	2.8	2.8
7	......	1,800	988	847	3,000	1,000	26	27	53	45	2.6	2.9
8	......	1,550	998	784	2,800	874	25	26	50	44	2.6	2.6
9	......	1,400	886	747	2,350	767	25	25	47	44	2.6	2.6
10	......	1,440	798	687	2,090	759	25	25	48	42	2.8	2.6
11	......	7,190	751	648	1,880	731	24	24	48	40	2.6	2.4
12	......	8,850	711	641	1,760	699	24	24	48	39	3.0	2.3
13	......	7,400	655	578	1,660	780	25	23	48	38	2.8	2.3
14	......	4,860	655	578	1,630	870	24	22	47	36	2.6	2.3
15	......	3,500	599	578	1,680	816	23	22	44	37	2.6	2.3
16	......	2,650	602	578	2,580	727	22	24	40	39	2.5	2.6
17	4,550	2,440	606	578	3,260	679	22	27	38	50	2.4	3.8
18	3,880	2,060	582	613	3,260	719	22	350	38	194	2.3	14.6
19	3,290	1,700	544	1,590	3,280	727	23	272	41	460	2.5	14.8
20	3,180	1,420	538	4,700	2,910	691	22	194	40	256	2.4	15.1
21	3,480	1,320	518	4,350	2,360	634	23	126	44	194	3.3	10.8
22	3,690	1,240	495	3,670	2,050	571	33	98	64	162	4.2	8.4
23	2,980	1,210	495	2,640	1,960	550	89	80	111	142	5.5	6.9
24	2,640	1,180	557	2,330	1,900	550	166	82	232	142	10.6	8.9
25	3,210	1,150	1,010	2,040	1,870	550	85	100	145	172	6.5	8.4
26	3,630	1,090	1,390	2,180	1,750	550	55	118	108	176	5.2	7.8
27	2,430	1,020	1,370	2,540	1,690	550	41	102	85	162	4.2	7.1
28	1,660	1,040	1,200	2,290	1,620	550	37	91	70	145	3.6	6.5
29	1,420	982	1,020	2,360	1,560	......	32	78	59	132	3.4	5.7
30	1,370	915	925	2,100	1,450	......	37	72	64	122	3.6	5.2
31	1,330	......	844	1,930	......	......	55	70	91	110	4.4	5.0
Mean	2,850	2,290	834	1,600	2,100	814	37.0	74.5	67.3	109	3.50	5.60
Mean per square mile	1.98	1.59	.579	1.11	1.46	.565	.468	.943	.295	.478	.254	.405
Run-off (depth in inches on drainage area)	1.10	1.77	.67	1.28	1.63	.59	.54	1.09	.34	.55	.29	.47

[a] All these discharges are based on well-defined rating curves.

Daily discharge, in second-feet, of Sorrels, Fish, and Miller creeks for 1910.

Day.	Sorrels Creek at mouth (drainage area, 21 square miles).[a]		Fish Creek below Solo Creek (drainage area, 21.5 square miles).[b]					Fish Creek at mouth (drainage area, 90.2 square miles).[a]		Miller Creek at mouth (drainage area, 16.7 square miles).[c]	
	July.	Aug.	June.	July.	Aug.	Sept.	Oct.	July.	Aug.	July.	Aug.
1	5.2	7.9	......	7.1	7.0	13.3	9.2	24	18.0	3.5	3.3
2	5.1	6.8	......	7.0	6.4	15.7	9.2	22	16.6	3.3	3.0
3	5.0	6.2	......	7.0	5.9	13.3	......	19.8	16.1	3.1	2.5
4	4.9	5.5	......	6.9	5.5	28	......	19.2	16.1	2.9	2.5
5	4.8	5.2	......	6.8	5.1	35	......	19.2	15.2	2.7	2.5
6	4.7	5.0	......	6.7	5.1	22	......	18.0	14.2	2.5	2.3
7	4.2	4.5	......	6.3	5.1	13.3	......	17.5	12.7	2.5	2.3
8	4.2	4.2	......	6.7	5.5	12.2	......	18.0	13.3	2.3	2.3
9	4.7	4.2	......	6.1	5.2	12.2	......	16.6	13.3	3.3	2.3
10	4.7	4.2	......	6.1	5.0	9.2	......	17.1	13.3	3.4	2.1
11	4.5	4.0	......	6.1	5.0	9.1	......	17.5	13.0	3.9	2.1
12	4.5	3.9	......	6.7	4.8	9.0	......	18.0	12.7	4.6	2.1
13	4.5	3.6	......	6.3	5.0	9.0	......	17.1	12.4	4.1	2.0
14	4.2	3.6	22	6.1	4.8	26	......	17.1	12.4	3.4	2.0
15	4.2	3.6	17.5	5.7	5.0	44	......	16.1	12.7	3.4	2.1
16	3.7	3.9	17.5	5.4	5.3	47	......	15.6	13.8	3.0	2.3
17	3.6	5.0	17.5	5.7	13.3	50	......	14.2	18.0	2.8	3.4
18	3.6	27	16.2	5.7	38	50	......	13.8	59	2.8	10.4
19	4.0	32	9.5	6.4	38	35	......	15.6	119	3.0	13.5
20	3.7	36	8.6	5.9	28	23	......	16.1	68	3.0	10.0
21	4.2	27	10.4	10.0	26	21	......	16.6	54	3.6	8.4
22	6.8	19.8	9.5	11.0	15.7	18.2	......	25	42	4.1	6.7
23	14.1	15.0	9.5	12.0	13.3	14.5	......	25	35	4.3	6.4
24	46	18.6	7.1	18.7	18.2	14.5	......	42	38	5.2	6.4
25	21	21	7.1	20.0	23	14.5	......	35	48	4.1	6.4
26	12.7	24	7.1	13.9	23	13.3	......	25	44	3.4	6.4
27	10.0	20	8.6	13.9	15.7	11.2	......	23	38	3.0	5.7
28	7.9	17.4	15.0	9.8	12.2	11.2	......	19.2	36	2.8	5.7
29	6.8	15.0	10.4	8.9	12.2	10.2	......	17.1	32	2.5	5.2
30	6.8	12.7	10.4	9.1	11.2	9.2	......	17.1	29	3.4	4.6
31	9.1	12.0	......	8.5	9.2	......	......	20	25	2.4	4.4
Mean	7.53	12.2	12.0	8.47	12.3	20.5	9.2	19.9	29.4	3.33	4.56
Mean per square mile	0.359	0.581	0.558	0.394	0.572	0.953	0.428	0.221	0.326	0.199	0.273
Run-off (depth in inches on drainage area)	0.41	0.67	0.35	0.45	0.66	1.96	0.03	0.25	0.38	0.23	0.31

[a] The discharges for Sorrels Creek at mouth and Fish Creek at mouth are based on well-defined rating curves.

[b] The channel of Fish Creek below Solo Creek shifted considerably during the period July 1 to August 9. The discharges for this interval were deduced by the indirect method for shifting channels.

[c] The bed of Miller Creek shifted to such an extent that three rating curves were needed to define the discharge, but sufficient measurements were made to render the results good.

Miscellaneous measurements in Chena River drainage basin in 1910.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
July 10	Elliott Creek at mouth	41.5	8.7	0.21
July 31	do	41.5	14.9	.36
July 7	Solo Creek at mouth	5.1	.89	.18
Aug. 9	do	5.1	.76	.15
Aug. 22	do	5.1	2.5	.49
July 7	Bear Creek at mouth	13.8	3.2	.23
Aug. 9	do	13.8	2.6	.19
Aug. 23	do	13.8	6.6	.48
July 7	Fairbanks Creek at mouth	18.9	3.8	.20
Aug. 9	do	18.9	2.7	.14
Aug. 23	do	18.9	7.4	.39
July 6	Miller Creek above Heim Creek	6.0	1.7	.28
Do	Heim Creek at mouth	4.0	.44	.11

CHATANIKA RIVER DRAINAGE BASIN.

Chatanika River is formed by the junction of Faith and McManus creeks, which drain the high ridge constituting the divide between the lower Tanana and Yukon basins. The river flows southwestward in a winding course through a long and rather narrow valley and unites with the Tolovana from the east about 30 miles above the confluence of that stream with the Tanana. Its course lies mostly to the west side of the valley, which is from half a mile to 7 miles wide and about 80 miles long. The drainage area of the river above its mouth is approximately 1,300 square miles.

Below the junction of Faith and McManus creeks the stream has a shifting, gravelly bottom. In low and medium stages it flows in a series of pools and rapids in a channel 75 to 200 feet wide; during the high-water period it may spread through several channels covering a width of 100 to 400 feet. This high-water channel is usually well defined by steep, alluvial banks ranging from 8 to 10 feet in height.

Below Poker Creek, a tributary from the right about 40 miles downstream from the junction of Faith and McManus creeks, the valley widens and the bottom lands become marshy and swampy. From the left the Chatanika receives Cleary, Eldorado, Dome, and Vault creeks and other less important streams from the mining district proper. Below these tributaries the valley narrows to a gorgelike channel, which it follows for about 10 miles; below this the dividing ridges disappear and the stream meanders through the low swampy grounds to the north of Tanana River. About 10 miles from its mouth Goldstream Creek, its largest tributary, joins it from the left.

The average elevation of the divides in the upper drainage area of the Chatanika is between 3,000 and 4,000 feet above sea level, and the altitude of the ridges bounding the valley on the east and west is about 2,000 feet. Below an altitude of 1,800 to 2,000 feet the slopes are heavily timbered.

The tributary streams from the right are short and precipitous, flowing through V-shaped valleys; those from the left have less precipitous courses and broader valleys and gradually lose themselves in the rather broad expanse of swamplike bottom lands.

Monthly discharge of Chatanika River for 1907-1910.

Chatanika River below Faith Creek.

[Drainage area, 132 square miles.]

Month	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1907.					
July 17-31	96	55	67.8	0.514	0.28
August	205	72	125	.947	1.09
September	1,990	119	342	2.59	2.89
The period, 76 days	1,990	55	178	1.31	4.26
1908.					
May 12-20	1,340	320	598	4.53	1.85
July 13-31	200	82	131	.992	.70
August	270	95	137	1.04	1.20
September	530	102	208	1.58	1.76
The period, 89 days	1,340	82	241	1.82	5.51
1910.					
May 25-31	683	320	473	3.58	.93
June	2,000	118	377	2.86	3.19
July	293	48	86.1	.652	.75
August	1,010	49	197	1.49	1.72
Sept. 1-25	430	141	233	1.77	1.65
The period, 124 days	2,000	48	235	1.78	8.24

Chatanika River below Poker Creek.

[Drainage area, 456 square miles.]

Month	Maximum.	Minimum.	Mean.	Mean per square mile.	Run-off (depth in inches on drainage area).
1907.					
June 20-30	250	192	228	0.500	0.20
July	283	167	211	.463	.53
August	1,160	216	428	.939	1.08
September	3,160	300	954	2.09	2.33
Oct. 1-14	860	232	506	1.11	.47
The period, 117 days	3,160	167	496	1.08	4.61
1908.					
May 16-31	4,120	1,730	2,730	5.99	3.56
June	2,280	283	984	2.16	2.41
July	942	204	332	.728	.84
August	455	192	284	.623	.72
September	1,160	266	461	1.01	1.12
Oct. 1-21	342	179	234	.513	.40
The period, 159 days	4,120	179	699	1.53	9.05
1909.					
May 9-31	3,620	474	1,870	4.10	3.51
June	1,220	152	416	.912	1.02
July	833	219	414	.910	1.05
August	1,740	179	530	1.16	1.34
September	219	130	151	.331	.37
Oct. 1-5	110	92	103	.226	.04
The period, 150 days	3,620	92	598	1.31	7.33
1910.					
May 17-31	1,900	600	944	2.07	1.16
June	3,260	248	686	1.50	1.67
July	822	104	196	.430	.50
August	2,720	95	481	1.05	1.21
September	1,410	298	553	1.21	1.35
Oct. 1-29	352	123	208	.456	.49
The period, 166 days	3,260	95	472	1.04	6.38

Daily discharge, in second-feet, of Chatanika River for 1910.

Day.	Chatanika River below Faith Creek[a] (drainage area, 132 square miles).					Chatanika River below Poker Creek[b] (drainage area, 456 square miles).					
	May.	June.	July.	Aug.	Sept.	May.	June.	July.	Aug.	Sept.	Oct.
1	......	639	109	92	146	......	1,020	269	144	361	280
2	......	632	108	80	144	......	1,020	262	145	350	263
3	......	646	81	70	141	......	892	214	144	351	263
4	......	569	65	65	172	......	861	174	140	376	263
5	......	683	78	62	276	......	682	193	134	674	257
6	......	339	68	62	368	......	600	173	125	967	160
7	......	249	62	60	348	......	600	165	124	561	138
8	......	223	60	58	315	......	500	154	125	502	134
9	......	310	60	56	281	......	456	144	126	471	134
10	......	2,000	58	55	241	......	1,770	132	123	397	132
11	......	1,030	56	55	212	......	3,260	126	122	358	123
12	......	502	55	54	185	......	1,610	130	117	330	126
13	......	302	54	53	162	......	1,460	136	114	315	175
14	......	223	53	51	175	......	1,020	128	111	570	257
15	......	182	52	49	430	......	456	111	95	1,410	352
16	......	202	52	51	310	......	372	110	98	1,120	326
17	......	206	51	68	293	1,900	333	127	142	1,060	298
18	......	144	51	477	268	1,560	298	104	455	917	277
19	......	149	49	1,010	238	655	280	127	2,020	723	263
20	......	157	48	907	216	600	263	133	2,720	625	239
21	......	182	53	477	209	1,020	263	136	1,720	581	205
22	......	339	99	245	202	988	248	112	923	569	200
23	......	220	276	175	182	655	347	218	1,010	551	180
24	......	202	293	202	154	800	329	544	624	445	180
25	683	178	127	200	146	1,350	294	822	503	376	180
26	329	172	102	276	......	655	296	268	502	361	180
27	320	202	92	260	......	655	263	212	499	357	168
28	348	157	75	238	......	600	250	186	484	305	134
29	477	141	70	209	......	600	252	170	480	298	134
30	542	118	106	175	......	955	270	161	445	298	......
31	610	......	106	157	......	1,160	......	146	396	......	......
Mean	473	377	86.1	197	233	944	686	196	481	553	208
Mean per square mile	3.58	2.86	0.652	1.49	1.77	2.07	1.50	0.430	1.05	1.21	0.456
Run-off (depth in inches on drainage area)	0.93	3.19	0.75	1.72	1.65	1.16	1.67	0.50	1.21	1.35	0.49

[a] The discharges for Chatanika River below Faith Creek are based on a well-defined rating curve.

[b] The discharges of Chatanika River below Poker Creek are obtained by adding to the flow of the river the amount of water diverted by the Chatanika ditch. It was not possible to determine the discharge of the ditch accurately on account of shifting channel conditions, but as the flow was uniform and not a large percentage of the total it is thought that the values given are correct within 5 to 10 per cent. A fish dam built below the gage resulted in a backwater effect on the gage from July 3 to Aug. 13, when the dam was washed out.

Daily discharge, in second-feet, of McManus, Charity, and Homestake creeks for 1910.

Day.	McManus Creek at mouth[a] (drainage area, 80 square miles).					Charity Creek above Homestake Creek.[b]					Homestake Creek at mouth[b] (drainage area, 5.6 square miles).		
	May.	June.	July.	Aug.	Sept.	May.	June.	July.	Aug.	Sept.	May.	June.	July.
1	......	242	23	42	64	......	60	......	4.0	14.8	......	42	3.0
2	......	183	23	34	59	......	42	......	3.8	13.3	......	35	2.8
3	......	175	24	32	59	......	77	......	3.6	11.8	......	42	2.3
4	......	152	23	26	80	......	44	......	3.4	14.8	......	27	2.0
5	......	225	42	23	160	......	41	......	3.2	13.5	......	35	2.9
6	......	156	36	23	199	......	32	......	3.2	12.0	......	20	2.6
7	......	104	23	23	187	......	27	......	3.2	10.0	......	17.4	2.6
8	......	85	23	21	168	......	42	......	3.2	9.0	......	15.2	2.7
9	......	120	22	19.0	141	......	55	......	3.2	8.0	......	34	2.8
10	......	760	21	18.0	120	......	77	......	3.2	7.0	......	56	2.9
11	......	486	21	17.0	104	......	41	3.6	3.2	7.0	......	36	2.9
12	......	277	21	17.0	80	......	......	3.5	3.2	7.0	......	17.4	......
13	......	152	21	15.0	69	......	......	3.4	3.2	7.0	......	11.0	......
14	......	104	20	15.0	97	......	......	3.3	3.1	7.0	......	8.4	......
15	......	85	19.0	13.0	282	......	......	3.2	3.0	7.0	......	8.0	......
16	......	85	19.0	13.0	225	......	......	3.2	6.0	7.0	......	11.0	......
17	......	69	18.0	16.0	187	......	......	3.2	9.0	7.0	......	8.8	......
18	......	59	17.0	42	160	......	......	3.2	12.0	7.0	......	7.4	......
19	......	57	17.0	277	138	......	......	3.2	17.9	7.0	......	7.4	......
20	......	53	17.0	387	152	......	......	3.2	......	7.0	......	7.7	......
21	......	59	18.0	183	148	......	......	5.1	......	7.0	......	30	......
22	......	277	24	104	138	......	......	5.1	......	7.0	......	22	......
23	......	110	32	75	94	......	......	7.2	......	7.0	......	11.0	......
24	......	97	110	94	80	......	......	9.4	......	7.0	......	9.1	......
25	359	91	55	130	72	......	......	8.0	......	7.0	......	5.3	......
26	183	80	32	145	......	22	......	7.0	......	7.0	16.3	4.6	......
27	160	100	23	138	......	22	......	6.0	......	7.0	49	4.2	......
28	175	97	23	123	......	32	......	4.0	......	7.0	39	4.2	......
29	242	72	21	107	......	44	......	3.2	......	......	29	4.6	......
30	255	30	51	85	......	60	......	5.1	......	......	42	4.6	......
31	277	......	59	69	......	77	......	4.3	......	......	50	......	......
Mean	236	155	29.0	75.0	131	42.8	48.9	4.64	4.98	8.58	37.6	18.2	2.68
Mean per square mile	2.95	1.94	0.362	0.938	1.64	......	......	......	......	......	6.71	3.25	0.479
Run-off (depth in inches on drainage area)	[a]0.77	2.16	0.42	1.08	1.52	......	......	......	......	......	1.50	3.63	0.20

[a] The discharges of McManus creek at mouth are based on a rating curve that is well defined between 50 and 400 second-feet.

[b] The discharges of Charity and Homestake creeks are only approximate on account of shifting channel conditions and insufficient measurements.

Miscellaneous measurements in the Chatanika River drainage basin in 1910.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-feet.*	*Sec.-feet.*
July 10	Smith Creek above Pool Creek	17	5.4	0.32
Aug. 1	do	17	7.3	.43
July 10	Pool Creek at mouth	14	4.8	.34
Aug. 1	do	14	8.8	.63
July 10	Hope Creek at mouth	20.3	12.3	.61
July 31	do	20.3	23	1.13
July 10	Deep Creek at mouth	10.8	2.4	.22
Do	Orphan Boy Creek at mouth	......	1.4	......
Aug. 2	First tributary below Sourdough Creek from right side at mouth.	5.1	1.5	.29
Do	Cripple Creek at mouth	12.3	2.8	.23
Do	Cassiar Creek at mouth	7.3	.72	.10
July 8	Flat Creek below Third Pup	7.0	1.1	.16
Aug. 2	Flat Creek below First Pup	16.9	3.6	.21
Aug. 3	Juniper Creek at mouth	8.7	2.0	.23
Do	Kokomo Creek above Rusty Gold Creek	26.1	3.8	.15
Aug. 5	Poker Creek at mouth	40.0	8.8	.22
Do	Poker Creek ditch near outlet	......	5.3	......

GOLDSTREAM CREEK DRAINAGE BASIN.

Goldstream Creek flows southwestward, in a narrow, winding course, between the drainage basin of Chatanika River on the right and the Little Chena and Tanana basins on the left, paralleling Chatanika River, which it enters from the east, and draining the central portion of the Fairbanks mining district. It is about 70 miles long and it drains an area of about 500 square miles. About 40 miles below its source it leaves the dividing ridges and for the remainder of its course to the Chatanika flows in a zigzag channel across the soft, mucky flats northwest of Tanana River. The stream bed is sandy and shifting, and the channel is deeply cut in the alluvial soil that forms the bottom lands.

The upper portion of the valley is drained by Pedro and Gilmore creeks, which join to form Goldstream Creek near Gilmore, about 12 miles north of Fairbanks. Fox Creek enters the main stream from the right about 2 miles below this junction.

Miscellaneous measurements in Goldstream Creek drainage basin in 1910.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-feet.*	*Sec.-feet.*
June 28...	Gilmore Creek near mouth	10.7	6.5	0.61
Do....	Pedro Creek near mouth	14.3	6.1	.43
Aug. 10..	Fox Creek near mouth	7.4	.45	.061

SALCHAKET DISTRICT.

DESCRIPTION.

The Tanana precinct, which includes the Salchaket district, embraces the area drained by the Tanana and its tributaries from and including Salcha River to a point on Tanana River south of Lake Mansfield. The larger streams included in this area are Salcha, Goodpaster, Volkmar, and Healy rivers from the north and Delta River from the south.

TANANA RIVER DRAINAGE BASIN.

Tanana River rises near the international boundary line and flows in a general northwesterly direction for about 440 miles to its junction with Yukon River at Fort Gibbon.

The river in general follows the north side of the valley and is one maze of channels and islands. At McCartys, just above the mouth of Delta River, which is 95 miles from Fairbanks by the Government road, it flows in three channels except at extreme low water, when the middle one is dry. During the summer of 1909 the Alaska Road Commission installed ferries on the right and left channels and bridged the center one.

Tenderfoot and Banner creeks, which have been the largest gold producers in the district, are tributary to the Tanana about 75 miles northeast of Fairbanks, at a point about halfway between Goodpaster and Salcha rivers and from the same side.

Canyon Creek is a small stream which flows into the main stream from the north about 5 miles below Richardson.

Salcha River rises opposite the head of the South Fork of Birch Creek, about 25 miles from the Yukon. The average fall of the river from the Splits to the mouth is 10 feet to the mile, and from a point about 2 miles from the summit of the divide at the headwaters it averages 19 feet to the mile. At the mouth, which is 40 miles from Fairbanks, a ferry, post office, store, and roadhouse are located and good accommodations are at hand for the traveler. Redmond Creek enters the Salcha from the south about 15 miles above the mouth. Junction and Mosquito creeks, which join to form Redmond Creek, drain an area 6 to 8 miles north of the Tanana and parallel to it.

Little Salcha River, which is tributary to the Tanana from the east, enters the river at a point midway between the town of Salchaket and the Salcha telegraph station.

GAGING STATIONS AND MEASURING POINTS.

The following list gives the locations at which gaging stations were maintained or discharge measurements made in 1910 in the Salchaket district:

Gaging stations and measuring points in Salchaket district, 1910.

Tanana River drainage basin:
- Banner Creek at mouth.
- Canyon Creek near mouth.
- Salcha River at mouth.
  - Junction Creek above Moose Lake outlet.
- Little Salcha River at road crossing.

Monthly discharge of Salcha River at mouth for 1909–10.

[Drainage area, 2,170 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1909.					
July 4-31	9,130	1,630	3,830	1.76	1.83
August	7,460	1,750	3,690	1.70	1.96
September	1,730	1,350	1,460	.67	.75
The period, 89 days	9,130	1,350	2,980	1.37	4.54
1910.					
May 12-31	6,640	2,180	3,040	1.40	1.04
June	8,220	1,740	3,560	1.64	1.83
July	6,120	1,120	2,000	.920	1.06
Aug. 1-19	5,590	930	1,880	.866	.61
The period, 100 days	8,220	930	2,990	1.38	4.54

Daily discharge, in second-feet, of Banner Creek, Salcha River, and Junction Creek for 1910.

Day.	Banner Creek near mouth[a] (drainage area, 21.5 square miles).				Salcha River at mouth[b] (drainage area, 2,170 square miles).				Junction Creek above Moose Lake outlet[a] (drainage area, 23.6 square miles).			
	June.	July.	Aug.	Sept.	May.	June.	July.	Aug.	June.	July.	Aug.	Sept.
1	......	6.1	19.3	7.2	......	4,390	4,150	3,090	......	5.3	30	4.6
2	......	4.0	14.0	7.8	......	4,050	3,360	2,660	......	4.6	20	6.7
3	......	3.1	12.2	8.8	......	3,360	2,740	2,180	......	4.3	14.5	6.2
4	......	3.1	8.8	10.5	......	3,090	2,040	1,640	......	4.3	8.6	6.2
5	......	7.8	7.2	11.2	......	2,520	1,760	1,520	......	5.8	5.8	25
6	......	7.8	5.6	10.5	......	2,660	2,260	1,310	......	6.2	4.6	22
7	......	7.8	5.6	10.5	......	2,300	2,040	1,310	......	5.8	4.3	14.5
8	......	6.1	5.0	9.8	......	1,740	1,580	1,310	8.6	4.6	4.3	10.2
9	......	4.6	5.0	8.8	......	3,000	1,310	1,260	7.2	4.6	4.3	8.6
10	......	4.6	5.0	7.8	......	6,010	1,160	1,120	269	4.3	4.0	8.6
11	......	3.1	5.0	7.8	......	7,480	1,120	1,120	193	3.8	4.0	7.9
12	......	3.1	4.2	8.8	4,130	8,220	1,120	1,120	85	5.3	3.8	7.2
13	......	3.1	4.2	12.2	5,780	7,060	1,420	1,120	41	4.6	3.8	7.2
14	......	2.5	2.7	11.2	6,320	5,170	2,040	1,000	17.3	4.3	4.0	9.4
15	......	2.5	2.7	11.2	6,180	3,360	1,970	930	11.2	3.8	4.3	12.2
16	......	2.0	5.6	17.5	6,640	2,660	1,760	930	9.4	3.8	4.3	20
17	......	2.5	5.0	15.7	5,000	3,270	1,420	2,480	7.9	3.8	4.6	34
18	......	2.5	5.6	8.8	6,010	2,920	1,120	4,030	6.2	3.8	5.0	27
19	......	2.5	9.6	12.2	4,650	2,580	1,120	5,590	5.8	3.8	7.2	14.5
20	4.6	2.5	12.9	10.5	4,350	2,480	1,310	......	5.3	4.3	10.2	11.2
21	4.0	2.5	10.5	8.8	4,710	2,380	1,210	......	5.0	3.0	12.2	11.2
22	4.0	3.1	9.6	10.5	3,750	2,270	1,120	......	4.6	4.0	7.9	......
23	4.0	11.1	8.8	12.2	3,180	2,550	1,120	......	4.6	10.2	6.2	......
24	4.0	11.1	8.8	14.0	3,910	2,830	2,830	......	4.3	10.2	5.8	......
25	4.0	4.6	8.2	15.7	5,480	2,830	6,120	......	4.0	17.3	5.8	......
26	13.5	3.1	8.2	15.0	5,550	2,830	2,740	......	4.6	12.2	5.3	......
27	7.8	3.1	7.8	14.0	4,050	3,950	2,410	......	5.3	8.6	5.3	......
28	7.8	2.5	7.8	15.7	3,750	3,180	2,110	......	5.3	6.2	5.0	......
29	7.8	3.1	7.2	14.0	3,750	3,000	1,520	......	5.0	4.6	4.6	......
30	7.8	23	7.2	12.2	2,180	2,740	1,520	......	5.3	3.8	4.3	......
31	......	26	7.2	......	4,750	......	2,490	......	......	34	4.3	......
Mean	6.30	5.63	7.63	11.4	3,040	3,560	2,000	1,880	3.11	6.62	7.04	13.1
Mean per square mile	0.293	0.262	0.355	0.530	1.40	1.64	0.920	0.866	1.32	0.281	0.298	0.555
Run-off (depth in inches on drainage area)	0.12	0.30	0.41	0.59	1.04	1.83	1.06	0.61	1.13	0.32	0.34	0.43

[a] The discharges at Banner and Junction creeks are only approximate on account of shifting channel conditions and insufficient measurements.
[b] The discharges of Salcha River at mouth are based on a rating curve that is well defined throughout.

Miscellaneous measurements in Salchaket district in 1910.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-feet.*	*Sec.-feet.*
June 21	Canyon Creek near mouth	4.7	0.45	0.091
June 22	Little Salcha River at road crossing	70	28	.40
Aug. 15	do	70	21	.30

CIRCLE DISTRICT.

DESCRIPTION.

The area north of the Yukon-Tanana divide between longitude 143° 40′ and 146° 50′ is known as the Birch Creek region of the Circle district. Generally speaking, it consists of two geographic divisions—a low, broad alluvial plain and a dissected plateau.

The northwestern portion of the low, broad plain forms the bottom lands of the Yukon Flats north of Crazy Mountains; the southeastern portion is an irregular area surrounded by a low ridge along the

Yukon, the Crazy Mountains, and the range of hills 20 to 40 miles farther south. This portion is cut by Birch and Crooked creeks; it is well timbered along these streams and contains large areas of meadow-like swamp land that furnish forage for both summer and winter use.

The plateau division, whose longer diameter trends east and west, lies between two distinct ridges—the eastern extensions of the White Mountains. The ridge to the south is high and barren and forms the main Yukon-Tanana divide; that to the north is lower, irregular, and barren, separates the upper tributaries of the Birch Creek basin from the lower, and is itself divided by the deep canyon-like gorge through which Birch Creek flows on its way to the Yukon.

At elevations of 2,000 feet or more above sea level the country is as a rule barren and rocky; below this altitude, especially in the flats where Birch and Crooked creeks join, considerable timber is found.

GAGING STATIONS AND MEASURING POINTS.

The following list gives the locations at which gaging stations were maintained or discharge measurements made in 1910 in the Circle district:

Gaging stations and measuring points in Circle district, 1910.

- Birch Creek drainage basin:
  - Birch Creek below Clums Fork.
  - Birch Creek at Fourteenmile House.
  - Fryingpan Creek below forks.
  - Great Unknown Creek near mouth.
  - Clums Fork at mouth.
  - McLean Creek at mouth.
  - North Fork of Birch Creek drainage basin:
    - North Fork of Birch Creek above Twelvemile Creek.
    - Ptarmigan Creek at mouth.
    - Golddust Creek 4½ miles above mouth.
    - Butte Creek at mouth.
    - Bear Creek at mouth.
    - Twelvemile Creek at mouth.
    - East Fork of Twelvemile Creek at mouth.
  - Crooked Creek drainage basin:
    - Crooked Creek at Central House.
    - Porcupine Creek above ditch.
    - Porcupine Creek below Bonanza Creek.
    - Bonanza Creek above ditch intake.
    - Mammoth Creek at Miller House.
    - Mammoth Creek ditch at intake.
    - Independence Creek at mouth.
    - Miller Creek at claim "No. 6 above."
    - Miller Creek at mouth.
    - Boulder Creek at trail crossing.
    - Deadwood Creek above Switch Creek.
  - Preacher Creek drainage basin:
    - Preacher Creek above Bachelor Creek.
    - Bachelor Creek below Costa Fork.
    - Bachelor Creek at mouth.
    - Costa Fork at mouth.

BIRCH CREEK DRAINAGE BASIN.

Birch Creek flows into Yukon River at a point almost exactly on the Arctic Circle and about 25 miles directly west of Fort Yukon. Its mouth is about 5 miles west of the confluence of Chandalar River with the Yukon.

The drainage comes almost entirely from the south and west through a complex system of watercourses, and in outline the basin is extremely unsymmetrical. The headwaters interlock with those of Little Chena and Chatanika rivers and flow east for about 60 miles to the junction of the South Fork, where the stream makes an abrupt turn northward. About 12 miles beyond this point it leaves the mountainous country and enters the lowlands of the Yukon, through which it sluggishly flows in a meandering channel for over 100 miles, roughly paralleling the Yukon at a distance varying from 10 to 20 miles.

The principal tributaries from the south and east are Clums Fork and the South Fork. From the north and west the North Fork and Harrison, Crooked, and Preacher creeks are the chief branches. The headwaters of the South Fork rise opposite those of Salcha and Charley rivers.

Monthly discharge of Birch Creek at Fourteenmile House for 1908 to 1910.

[Drainage area, 2,150 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1908.					
June 26-30	1,190	1,020	1,090	0.507	0.09
July	2,630	847	1,140	.530	.61
August	1,620	825	1,080	.502	.58
Sept. 1-29	6,070	900	2,150	1.00	1.08
The period, 96 days	6,070	825	1,423	1.48	2.36
1909.					
May 15-31	9,970	3,320	5,930	2.76	1.74
June	8,640	1,860	3,410	1.59	1.77
July	8,280	960	2,200	1.02	1.18
August	3,020	974	1,830	.851	.98
September	960	730	799	.372	.42
Oct. 1-2	792	792	792	.368	.03
The period, 141 days	9,970	730	2,510	1.17	6.12
1910.					
May 13-31	6,620	3,200	4,790	2.23	1.58
June	6,000	1,160	2,500	1.16	1.29
July	5,460	551	1,430	.665	.77
August	1,880	432	950	.442	.51
September	3,280	1,040	1,620	.753	.84
Oct. 1-6	1,140	1,080	1,090	.507	.11
The period, 147 days	6,620	432	2,010	.935	5.10

Daily discharge, in second-feet, of Birch Creek and Fryingpan Creek for 1910.

Day.	Birch Creek below Clums Fork [a] (drainage area, 600 square miles).				Birch Creek at Fourteenmile House [b] (drainage area, 2,150 square miles).						Fryingpan Creek below the forks [c] (drainage area 15.9 square miles).		
	June.	July.	Aug.	Sept.	May.	June.	July.	Aug.	Sept.	Oct.	June.	July.	Aug.
1	......	1,010	550	457	......	4,070	3,690	1,680	1,040	1,140	......	6.7	4.6
2	......	604	424	508	......	3,370	2,860	1,430	1,180	1,080	......	5.8	3.8
3	......	391	353	487	......	2,900	2,070	1,200	1,430	1,080	......	5.2	3.4
4	......	296	272	497	......	2,810	1,680	984	1,410	1,080	......	4.9	3.2
5	......	2,610	237	666	......	2,420	1,610	756	1,380	1,080	......	6.7	2.8
6	......	1,370	220	881	......	2,190	5,460	735	1,650	1,080	......	6.5	2.6
7	......	816	188	684	......	1,840	3,060	648	1,680	......	......	5.4	2.4
8	518	539	175	593	......	1,590	2,360	587	1,550	......	5.4	4.9	2.4
9	566	409	164	539	......	1,480	1,810	605	1,380	......	11.2	4.8	2.3
10	2,030	349	147	497	......	2,040	1,200	648	1,250	......	17.0	4.5	2.3
11	2,610	296	147	477	......	3,950	1,030	623	1,200	......	15.2	5.7	2.3
12	2,660	284	142	438	......	6,000	968	575	1,200	......	13.6	6.2	2.2
13	1,420	307	125	396	3,810	4,920	900	527	1,120	......	12.0	7.2	2.2
14	848	258	120	424	4,260	2,980	830	471	1,140	......	10.5	5.8	2.1
15	604	207	123	1,810	5,240	2,260	760	460	1,180	......	8.9	5.4	2.0
16	604	169	120	1,860	6,120	1,930	690	432	2,840	......	7.3	4.9	2.2
17	529	161	125	1,760	6,070	1,680	620	432	3,280	......	5.7	4.3	2.1
18	462	276	357	1,560	5,880	1,600	551	449	3,220	......	5.4	6.5	......
19	383	409	1,710	1,230	5,020	1,460	952	605	2,800	......	5.1	5.8	......
20	374	296	1,130	848	4,540	1,370	1,200	1,880	2,320	......	4.9	5.3	......
21	400	233	720	783	4,260	1,280	920	1,550	1,780	......	7.2	5.4	......
22	2,080	227	577	649	4,210	1,560	808	1,360	1,510	......	8.8	5.8	......
23	1,100	269	539	593	4,370	3,320	770	1,180	1,430	......	6.8	6.0	......
24	733	550	457	561	4,730	2,440	808	960	1,410	......	6.0	6.3	......
25	467	561	572	577	6,140	1,460	1,120	1,000	1,380	......	5.3	5.7	......
26	378	353	783	599	6,620	1,250	1,200	1,230	1,410	......	5.1	2.7	......
27	344	276	745	561	6,000	1,160	1,020	1,410	1,450	......	5.1	2.6	......
28	396	233	835	555	3,670	1,710	830	1,380	1,430	......	5.3	2.5	......
29	1,150	194	696	524	3,370	4,110	770	1,300	1,320	......	5.2	2.5	......
30	1,680	340	599	438	3,200	3,900	770	1,230	1,200	......	9.0	11.0	......
31	......	752	524	......	3,460	......	936	1,120	......	......	......	7.6	......
Mean	971	485	448	748	4,790	2,500	1,430	950	1,620	1,090	8.09	5.50	2.64
Mean per square mile	1.62	0.808	0.747	1.25	2.23	1.16	0.665	0.442	0.753	0:507	0.509	0.346	0.166
Run-off (depth in inches on drainage area)	1.38	0.93	0.86	1.40	1.58	1.29	0.77	0.51	0.84	0.11	0.44	0.40	0.10

[a] The discharges of Birch Creek below Clums Fork are based on a well-defined rating curve below 700 second-feet. Above 700 second-feet the curve was extended by means of the area and velocity curves, and it is believed to represent the true relation of gage height to discharge up to 2,000 second-feet.
[b] The discharges of Birch Creek at Fourteenmile House are based on a rating curve well defined between 500 and 2,300 second-feet.
[c] The discharges of Fryingpan Creek are based on a rating curve well defined between 2.5 and 5.5 second feet.

Miscellaneous measurements in Birch Creek drainage basin in 1910.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
July 26	Great Unknown Creek near mouth	41.2	16.7	0.40
July 25	Clums Fork at mouth	172	118	.69
Do	McLean Creek at mouth	15.4	3.0	.20

NORTH FORK OF BIRCH CREEK DRAINAGE BASIN.

Eagle and Ptarmigan creeks, whose headwaters are opposite those of Crooked Creek, join to form the North Fork of Birch Creek. Below the junction the North Fork takes a southwestward course for about 7 miles, to the mouth of Twelvemile Creek, where it turns abruptly to the south and follows that direction for about 8 miles. Here its waters unite with those of Harrington Fork to form Birch Creek proper, which flows east to its confluence with the South Fork, a distance of approximately 45 miles.

Beginning at the head, the main tributaries from the north are Fish, Bear, and Twelvemile creeks. From the south, in the same order, Golddust and Butte creeks are the only important streams.

Miscellaneous measurements in North Fork of Birch Creek drainage basin in 1910.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
July 28	North Fork of Birch Creek above Twelvemile Creek.	87.1	55	0.63
Do	Ptarmigan Creek at mouth	19.0	15.0	.79
July 27	Golddust Creek 4½ miles above mouth	9.5	8.6	.90
July 28	Butte Creek at mouth	9.2	2.2	.24
Do	Bear Creek at mouth	12.4	6.7	.54
July 13	Twelvemile Creek at mouth	44.5	18.9	.42
July 28	do	44.5	14.6	.33
June 9	East Fork of Twelvemile Creek at mouth	22.9	60.0	2.62
July 13	do	22.9	7.4	.32
July 28	do	22.9	9.2	.40

CROOKED CREEK DRAINAGE BASIN.

Crooked Creek, which is formed by the junction of Mammoth and Porcupine creeks, meanders through a rather broad valley for about 30 miles and discharges its waters into Birch Creek about 10 miles above the Fourteenmile House. Not far below the Central House the valley loses its identity in the flats of Birch Creek.

Mastodon and Independence creeks unite to form Mammoth Creek, which receives Miller Creek about 2 miles below this junction from the west. The total length of that portion of the stream called Mammoth Creek is less than 4 miles.

Deadwood and Boulder creeks are tributaries from the south, below and above the Central House, respectively. They follow parallel courses about 3 miles apart, with a length of about 18 miles.

Albert Creek, the principal tributary from the north, drains the southern slope of the Crazy Mountains.

Daily discharge, in second-feet, of Crooked, Porcupine, and Bonanza creeks for 1910.

Day.	Crooked Creek at Central House[a] (drainage area, 161 square miles).				Porcupine Creek[b] above ditch intake (drainage area, 17.8 square miles).		Porcupine Creek below Bonanza Creek[c] (drainage area, 39.9 square miles).					Bonanza Creek[b] above ditch intake (drainage area, 7.9 square miles).	
	May.	June.	July.	Aug.	July.	Aug.	May.	June.	July.	Aug.	Sept.	June.	July.
1	......	139	348	173	15	23	......	100	38	42	9.7	38	19
2	......	173	173	91	12	17.7	......	82	29	31	9.7	32	15
3	......	225	112	74	10	11.4	......	102	23	25	9.5	36	10
4	......	234	74	61	9.2	11.4	......	85	19.7	22	9.3	30	9
5	......	126	112	50	14	8.8	......	73	48	17.8	10.9	29	32
6	......	139	192	45	11	7.1	......	64	38	10.9	12.4	23	25
7	......	112	112	32	5.0	6.7	......	49	27	12.6	12.4	20	14
8	......	102	74	29	5.0	6.7	......	43	23	11.6	11.8	20	12
9	......	91	68	......	3.7	5.4	......	68	24	10.9	11.6	24	13
10	......	300	61	......	5.0	5.0	......	131	19.9	10.5	11.3	42	10
11	......	255	56	......	4.5	4.5	......	92	18.1	10.5	11.3	35	9
12	......	212	50	......	3.7	4.0	......	77	17.2	9.7	11.3	30	8
13	......	173	45	......	3.7	4.0	......	60	17.0	9.7	10.9	21	8
14	......	139	40	......	4.0	3.7	......	46	15.6	9.3	11.3	16	7
15	173	112	36	......	4.0	3.7	......	44	10.9	9.0	38	15	5
16	173	102	33	......	2.9	3.7	......	55	10.1	9.3	40	19	5
17	112	112	30	......	3.0	3.2	......	46	10.5	9.3	32	16	5
18	102	102	255	......	30	3.7	......	36	71	9.5	26	12	30
19	91	82	173	......	27	......	......	41	40	9.3	22	14	18
20	112	74	126	......	17.7	......	......	57	28	9.9	17.6	19	13
21	126	112	102	......	12.8	......	......	174	24	9.8	......	28	11
22	139	348	112	......	10.1	......	......	134	22	9.8	......	30	10
23	112	255	126	......	9.2	......	......	62	22	9.7	......	27	11
24	139	173	112	......	11.9	......	......	49	29	9.7	......	24	16
25	212	112	91	......	11.4	......	......	36	25	9.7	......	15	12
26	112	91	74	......	9.6	......	......	36	20	10.3	......	18	9
27	74	91	61	......	8.4	......	......	43	18.5	10.7	......	18	8
28	50	173	50	......	7.1	......	......	46	12.9	10.5	......	20	8
29	173	397	40	......	7.1	......	51	76	16.2	10.1	......	35	8
30	234	448	32	......	62	......	73	60	173	9.9	......	30	27
31	300	......	212	......	41	......	127	......	74	9.7	......	......	30
Mean	143	173	103	69.4	12.3	7.43	83.7	68.9	31.1	12.9	16.4	24.5	13.5
Mean per square mile	0.888	1.07	0.640	0.431	0.691	0.417	2.10	1.73	0.779	0.323	0.411	3.10	1.71
Run-off (depth in inches on drainage area)	0.56	1.19	0.74	0.13	0.80	0.28	0.23	1.93	0.90	0.37	0.32	3.46	1.97

[a] Discharges of Crooked Creek at Central House are based on a rating curve well defined between 30 and 350 second-feet.

[b] The discharges of Porcupine and Bonanza creeks above ditch intakes are only approximate on account of shifting channel conditions.

[c] The discharges of Porcupine Creek below Bonanza Creek are based on a rating curve fairly well defined between 10 and 60 second-feet.

Daily discharge, in second-feet, of Mammoth and Deadwood creeks for 1910.

Day.	Mammoth Creek at Miller House[a] (drainage area, 37.1 square miles).			Deadwood Creek above Switch Creek[b] (drainage area, 21.3 square miles).				
	May.	June.	July.	May.	June.	July.	Aug.	Sept.
1	......	80	47	......	58	68	15.3	5.0
2	......	95	25	......	58	25	11.0	5.5
3	......	77	21	......	55	15.3	8.7	5.0
4	......	66	30	......	39	13.2	7.7	5.0
5	......	66	90	......	35	18.2	6.4	5.8
6	......	62	54	......	27	13.2	6.4	6.4
7	......	54	33	......	27	11.0	5.8	5.0
8	......	54	25	......	16.4	11.0	5.8	5.0
9	......	63	17.5	......	39	7.7	5.0	5.0
10	......	79	17.5	......	35	6.4	5.0	5.0
11	......	64	17.5	......	41	6.4	5.0	5.2
12	......	63	17.5	......	31	5.8	4.5	5.5
13	......	58	17.5	......	27	5.0	4.5	6.4
14	......	49	21	......	21	5.0	4.3	7.7
15	......	48	17.5	......	21	5.0	3.8	25
16	......	53	14.8	......	21	4.5	3.8	18.2
17	30	51	19.0	......	21	8.4	3.8	18.2
18	47	30	11.8	......	15.3	50	5.0	15.3
19	47	32	49	......	15.3	25	5.5	13.2
20	35	49	37	......	18.2	13.2	6.4	11.0
21	25	91	36	......	21	13.2	5.7	......
22	17.5	77	25	......	25	13.2	5.0	......
23	54	61	25	......	21	8.7	4.5	......
24	70	33	35	......	15.3	8.4	3.8	......
25	47	25	25	......	13.2	7.2	5.5	......
26	45	53	21	......	11.0	6.4	5.0	......
27	44	67	17.5	......	11.0	5.5	6.4	......
28	41	47	16.4	......	98	5.5	5.0	......
29	65	115	14.8	......	102	9.4	5.8	......
30	78	47	48	66	44	27	5.5	......
31	93	......	38	77	......	19.9	5.0	......
Mean	49.2	60.3	32.0	71.5	32.8	14.2	5.84	8.92
Mean per square mile	1.33	1.63	0.863	0.336	1.54	0.667	0.274	0.414
Run-off (depth in inches on drainage area)	0.74	1.82	0.99	0.25	1.72	0.77	0.32	0.31

[a] The discharges of Mammoth Creek below Miller House are obtained by adding to the discharge of the creek the amount of water diverted by the Mammoth Creek mining ditch. They are only approximate for certain periods during low water on account of insufficient data regarding the flow of the ditch.
[b] The discharges of Deadwood Creek above Switch Creek are based on a well-defined curve throughout.

Daily discharge, in second-feet, of Bonanza Creek ditch at intake for 1910.

Day.	May.	June.[a]	July.[a]	Aug.	Day.	May.	June.[a]	July.[a]	Aug.
1	......	18.9	19.0	17.6	21	......	18.9	10.5	......
2	......	19.2	13.0	13.1	22	......	0	10.2	......
3	......	21	9.6	10.2	23	......	0	10.5	......
4	......	23	8.4	8.4	24	......	24	15.7	......
5	......	23	28	6.9	25	......	14.4	11.9	......
6	......	20	20	......	26	......	15.7	8.7	......
7	......	17.3	13.3	......	27	......	17.3	8.0	......
8	......	16.0	11.5	......	28	14.7	16.9	0	......
9	......	20	12.4	......	29	14.4	26	0	......
10	......	22	9.4	......	30	13.2	28	26	......
11	......	23	8.4	......	31	15.0	......	27	......
12	......	23	7.7	......					
13	......	20	7.7	......	Mean	14.3	17	11.6	11.2
14	......	16.0	6.6	......					
15	......	14.2	0	......					
16	......	18.6	0	......					
17	......	15.4	0	......					
18	......	12.1	27	......					
19	......	13.8	17.6	......					
20	......	18.9	12.2	......					

[a] A change in the relation of gage height to discharge occurred during the period June 6 to July 15. Discharges for this interval were derived by the indirect method for shifting channels.

Miscellaneous measurements in Crooked Creek drainage basin in 1910.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
May 29	Mammoth Creek ditch at intake		33	
June 5	do		34	
July 14	Independence Creek at mouth	13.2	4.6	0.35
July 23	do	13.2	6.8	.52
May 29	Miller Creek at claim "No. 6 above"	7.2	11.1	1.54
June 5	do	7.2	17.4	2.42
July 14	do	7.2	3	.42
Do	Miller Creek at mouth	10.5	3	.29
July 23	do	10.5	6	.57
July 21	Boulder Creek at trail crossing	38.8	25	.64

PREACHER CREEK DRAINAGE BASIN.

Preacher Creek rises near the headwaters of Chatanika River and Beaver Creek and flows generally northeastward for about 65 miles, entering Birch Creek about 50 miles from the Yukon. It drains an area of 1,090 square miles, ranging in elevation from over 5,000 feet at the head to about 700 feet at the Birch Creek flats.

The main tributaries are the North Fork from the north and Loper and Rock creeks from the south. Bachelor Creek is a small but economically important branch from the south near the head.

Daily discharge in second-feet of Bachelor Creek below Costa Fork for 1910.[1]

[Drainage area, 11.4 square miles.]

July 11	6.6	July 21	7.6
July 12	6.4	July 25	8.1
July 13	5.9	July 26	7.6
July 14	5.3	July 27	7.4
July 15	5.2	July 28	7.1
July 16	5.0	July 29	7.0
July 17	5.6	July 30	8.5
July 18	8.5	Mean	6.93
July 19	8.2		
July 20	7.8		

Miscellaneous measurements in Preacher Creek drainage basin in 1910.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
July 29	Preacher Creek above Bachelor Creek	94.7	45	0.48
Do	Bachelor Creek at mouth	26.4	7.6	.29
July 11	Costa Fork at mouth	4.5	2.1	.47

[1] The discharges are only approximate on account of shifting channel conditions.

FORTYMILE DISTRICT.

LOCATION OF AREA.

It seems desirable in a water-supply discussion to make the boundaries of the districts described coincide with those of certain drainage areas rather than to make them conform with those of precincts or recording districts, which may include partial drainage areas, as in the Fortymile and Eagle precincts. Therefore the Fortymile district will be considered to be the area drained by Fortymile River and its tributaries. This area has been topographically surveyed and is covered by three maps[1] separately published or in process of publication. The topography, geology, and gold placers of this area have been described by Prindle.[2]

GAGING STATIONS AND MEASURING POINTS.

The following list gives the locations at which gaging stations were maintained or discharge measurements made in 1910 in the Fortymile district:

Gaging stations and measuring points in Fortymile district, 1910.

- Fortymile River drainage basin:
  - Fortymile River at Steele Creek.
  - King Solomon Creek at mouth.
  - Liberty Creek at mouth.
  - Dome Creek at trail crossing.
  - Steele Creek at mouth.
  - Canyon Creek below Squaw Gulch.
  - Squaw Gulch at claim "No. 1 above."
  - South Fork of Fortymile River drainage basin:
    - South Fork of Fortymile River below Franklin Creek.
    - Mosquito Fork below Kechumstuk Creek.
    - Kechumstuk Creek at mouth.
    - Gold Creek above Willow Creek.
    - Gold Creek 1 mile above mouth.
    - Walker Fork above Poker Creek.
    - Walker Fork above Twelvemile Creek.
    - Poker Creek one-half mile above mouth.
    - Davis Creek 1 mile above mouth.
    - Wade Creek at claim "No. 10 above."
    - Napoleon Creek at mouth.
    - Buckskin Creek above Fortyfive Pup.
    - Fortyfive Pup at claim No. 13.

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[1] Fortymile quadrangle: Maps can be obtained from the Director, U. S. Geol. Survey, Washington, D. C., at 5 cents per copy.

Circle quadrangle: Contained in Bulletin 295, which can be obtained from the Director, U. S. Geol. Survey; also in print as a separate publication, price 10 cents.

Area south of Circle and Fortymile quadrangles: In process of compilation.

[2] Prindle, L. M., The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, Alaska: Bull. U. S. Geol. Survey No. 251, 1905.

Fortymile River drainage basin—Continued.
- North Fork of Fortymile River drainage basin:
  - North Fork of Fortymile River above Slate Creek.
  - North Fork of Fortymile River above Middle Fork.
  - North Fork of Fortymile River at the "kink."
  - Slate Creek at mouth.
  - Champion Creek below Arkansas Creek.
  - Champion Creek above Bear Creek.
  - Champion Creek at mouth.
  - Bear Creek at mouth.
  - Middle Fork of Fortymile River at mouth.
  - Bullion Creek at mouth.
  - Hutchinson Creek below Confederate Creek.
  - Hutchinson Creek below Montana Creek.
  - Montana Creek at claim No. 7.

FORTYMILE RIVER DRAINAGE BASIN.

Fortymile River[1] is tributary to Yukon River at longitude 140° 30′ west and latitude 64° 30′ north, about 50 miles below Dawson, Yukon Territory, and approximately the same distance above the town of Eagle, Alaska. It has a drainage area of 6,350 square miles, about 4 per cent of which lies in Canadian territory. The basin is roughly symmetrical and the extreme north-south and east-west dimensions are each about 100 miles. The stream flow is predominantly from west to east. The main Fortymile River is formed by the North and South forks, which unite about 40 miles in an air line from the Yukon. On the north the tributaries interlock with those of Mission Creek and Seventymile and Charley rivers in high, rocky ridges of which Glacier Mountain is the most prominent feature. From the west Goodpaster, Volkmar, and Healy rivers take the adjoining drainage from mountains equally rugged. In the southeast portion the streams head in a country of relatively low relief and at a distance of only a few miles from Tanana River. Ladue Creek and Sixtymile River form the opposing drainage on the east and southeast, the moderately low dividing range being accentuated by several large dome-shaped mountains.

Near the international boundary the river flows through a narrow rock canyon from which it emerges into an open valley and takes a more moderate grade to its union with the Yukon. A prominent feature of the lower Fortymile is the well-defined bench which marks the elevation of an earlier valley floor. At Steele Creek the bench is about 500 feet above the water level. The plane of the present valley floor and that of the older one become coincident near the mouth of Kechumstuk Creek at an elevation of about 2,000 feet above sea level.

The principal tributaries below the forks are Steele, Canyon, Smith, and Moose creeks from the south and O'Brien Creek from the north.

[1] So called because its confluence with Yukon River is 40 miles below the old trading post of Fort Reliance.

Daily discharge, in second-feet, of Fortymile River at Steele Creek for 1910.[a]

[Drainage area, 5, 890 square miles.]

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1	....	7,980	575	896	21	....	880	1,620	1,760
2	....	5,630	584	880	22	....	730	1,560	1,530
3	....	4,260	580	880	23	....	737	1,320	1,300
4	....	2,920	567	1,230	24	....	758	1,210	....
5	....	2,360	543	1,450	25	....	772	1,190	....
6	....	2,660	521	1,450	26	....	880	1,280	....
7	....	2,160	507	1,540	27	....	786	1,250	....
8	....	1,720	535	1,470	28	13,300	706	1,210	....
9	....	1,270	7,470	1,270	29	13,900	682	1,180	....
10	....	2,240	7,240	1,150	30	11,000	630	1,180	....
11	....	2,130	4,900	1,130	31	....	580	1,020	....
12	....	2,060	3,590	1,130	Mean	12,700	1,870	1,780	1,600
13	....	2,090	2,660	1,080	Mean per square mile	2.16	0.317	0.302	0.272
14	....	2,280	2,130	1,030	Run-off (depth in inches on drainage area)	0.24	0.36	0.35	0.23
15	....	1,790	1,670	1,050					
16	....	1,660	1,360	2,720					
17	....	1,500	1,280	3,080					
18	....	1,210	1,490	3,440					
19	....	1,030	1,450	2,890					
20	....	952	1,450	2,440					

[a] The rating curve for this station is fairly well defined for all stages.

Daily discharge, in second-feet, of Steele, Canyon, and Squaw creeks for 1910.

Day.	Steele Creek at mouth [a] (drainage area, 12.5 square miles).				Canyon Creek below Squaw Gulch [a] (drainage area, 58.4 square miles).			Squaw Gulch at claim "No. 1 above" [b] (drainage area, 24.4 square miles).		
	June.	July.	Aug.	Sept.	July.	Aug.	Sept.	July.	Aug.	Sept.
1	......	4.6	0.4	3.0	......	9.6	18.0	......	1.2	5.9
2	......	3.2	.3	3.0	11.7	6.8	18.0	......	1.0	5.9
3	......	2.1	.3	3.0	10.3	6.8	18.0	3.8	1.2	8.9
4	......	1.5	.2	3.0	10.3	6.8	39	4.5	1.0	6.9
5	......	1.4	.1	3.4	12.6	6.8	39	3.8	1.0	5.9
6	......	2.8	.1	10.5	34	5.7	15.0	10.5	.8	10.5
7	......	2.1	.2	8.0	72	6.8	15.0	8.9	.8	11.8
8	......	1.7	5.6	5.6	12.6	72	39	5.9	27	10.5
9	......	1.1	254	5.0	12.6	348	39	4.5	143	10.5
10	......	.9	26	5.0	12.6	288	50	3.8	43	14.8
11	......	.9	10.5	4.0	12.6	181	57	5.9	27	16.8
12	......	.8	6.2	4.0	34	137	72	7.8	10.5	21
13	......	5.6	4.2	4.0	97	116	72	70	7.8	27
14	......	5.0	3.0	4.0	72	80	72	52	5.9	52
15	......	3.0	2.2	4.0	51	72	80	31	75	66
16	......	2.1	4.0	8.0	29	62	88	15.0	27	79
17	......	1.5	4.0	14.6	15.0	50	88	8.9	6.9	60
18	......	1.2	4.6	12.5	18.0	39	97	5.9	10.5	27
19	......	1.0	5.0	10.5	12.6	12.6	116	3.8	13.4	32
20	......	.9	4.0	8.0	8.6	18.0	......	3.1	8.9	30
21	......	.8	3.4	6.5	12.6	15.0	......	3.1	5.9	29
22	......	.8	2.7	......	15.0	18.0	......	2.6	3.1	28
23	......	.8	2.6	......	18.0	25	......	2.6	5.9	27
24	......	.7	2.8	......	10.3	29	......	2.2	8.9	27
25	......	.6	3.4	......	10.3	34	......	2.2	11.8	27
26	......	.5	8.0	......	10.3	39	......	1.8	11.8	13.4
27	......	.4	5.0	......	12.6	44	......	1.5	10.5	10.5
28	36	.4	6.5	......	8.6	15.0	......	1.2	10.5	10.5
29	16.2	.4	5.0	......	6.8	8.6	......	1.0	4.5	......
30	8.0	.3	3.4	......	8.6	12.6	......	1.0	6.9	......
31	......	.2	3.0	......	8.6	18.0	......	1.0	5.9	......
Mean	20.1	1.59	12.3	6.17	22.0	57.5	54.3	9.29	16.1	24.1
Mean per square mile	1.61	0.127	0.984	0.494	0.377	0.984	0.930	0.381	0.660	0.988
Run-off (depth in inches on drainage area)	0.18	0.15	1.13	0.38	0.42	1.13	0.66	0.41	0.76	1.03

[a] The discharges for these stations are well defined below 40 second-feet.
[b] The discharges for this station are fairly well defined below 15 second-feet.

Miscellaneous measurements in Fortymile River drainage basin in 1910.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
June 27	King Solomon Creek at mouth	54.2	17.3	0.32
July 30	....do	54.2	5.7	.11
June 27	Liberty Creek at mouth	43.1	19.4	.45
July 30	....do	43.1	4.9	.11
June 28	Dome Creek at trail crossing	24.9	14.8	.59

SOUTH FORK OF FORTYMILE RIVER DRAINAGE BASIN.

The South Fork is formed by the junction of Dennison and Mosquito forks, which unite about 25 miles above its mouth. Below the forks the river flows due east for about 4 miles to a point just below the mouth of Atwater Creek, where it makes a right-angle turn and flows northward to its confluence with the North Fork.

The principal tributaries from the west in sequence upstream are Butte, Buckskin, and Franklin creeks, and from the east Uhler and Napoleon creeks, Walker Fork, and Atwater Creek are the main drainage channels.

Walker Fork, which is the largest tributary of the South Fork, joins the main stream about 16 miles from its mouth, a short distance above Napoleon Creek. It rises in Canadian territory about 2 miles beyond the boundary, flows westward for about 35 miles, and drains a total area of 414 square miles. Its principal tributaries from the north are Wade, Twelvemile, Davis, and Poker creeks. From the south, Liberty Fork and Cherry Creek are the most important affluents.

Mosquito Fork, the left branch of the South Fork, heads at an elevation of 3,000 to 4,000 feet in a ridge paralleling Tanana River and about 20 miles from that stream. The general direction of flow is northeast for about 75 miles, and the drainage area comprises 1,120 square miles. Chicken Creek is the first tributary from the north, and although of small drainage area it is economically important as a gold producer. Gold Creek joins from the north about 12 miles above Dennison Fork, and Kechumstuk Creek enters from the same side about 8 miles farther upstream. Near the mouth of Kechumstuk Creek, at an elevation of about 2,000 feet, an abrupt decrease in stream gradient is noticeable, and the valley above this place widens and becomes swampy. The valley floor narrows again about 8 miles above, at a point where a spur from the south approaches the stream. This spur marks the lower end of the flat swampy area known as Mosquito Flats, which constitutes a large portion of the upper drainage area of Mosquito Fork. These flats extend along the stream for about 20 miles and at some places are 12 to 14 miles wide. They are a tangle of lakes and sloughs, and it is said that during a wet season they are practically covered with water.

Dennison Fork has its source in a country similar to that of Mosquito Fork, and the ridge separating its drainage from that of Tanana River parallels the Tanana at a distance varying from 4 to 10 miles. The flat basin at the head is not so pronounced as that of Mosquito Fork, but the valleys are broad and swampy, with very gentle slopes. The drainage area is 1,540 square miles, about equally divided between two forks which unite to form the main stream about 12 miles above its mouth.

Daily discharge, in second-feet, of South Fork, Mosquito Fork, and Kechumstuk Creek for 1910.[a]

Day.	South Fork of Fortymile River at Franklin Creek (drainage area, 3,180 square miles).			Mosquito Fork below Kechumstuk Creek (drainage area, 824 square miles).				Kechumstuk Creek at mouth (drainage area, 189 square miles).			
	July.	Aug.	Sept.	July.	Aug.	Sept.	Oct.	July.	Aug.	Sept.	Oct.
1	......	179	420	......	52	65	49	......	13.0	14.8	14.8
2	......	179	420	......	49	63	41	......	13.0	14.8	13.0
3	......	166	468	......	47	58	37	......	12.7	13.9	11.8
4	......	153	468	......	43	56	......	......	12.4	13.5	......
5	......	153	420	......	43	56	......	......	11.8	15.8	......
6	......	134	420	......	41	58	......	......	11.1	17.1	......
7	......	134	420	325	40	58	......	80	10.5	17.6	......
8	......	179	420	286	45	56	......	69	12.7	17.6	......
9	735	5,120	420	227	234	56	......	52	178	16.7	......
10	683	4,060	420	202	193	56	......	42	132	16.7	......
11	631	2,530	420	175	179	56	......	39	87	15.8	......
12	540	1,900	420	175	186	53	......	32	49	15.8	......
13	709	1,420	420	197	149	52	......	97	39	14.8	......
14	870	968	468	193	130	53	......	92	32	15.8	......
15	842	787	468	197	102	58	......	65	24	18.3	......
16	870	709	516	238	89	65	......	49	21	25	......
17	912	761	516	193	83	72	......	39	24	30	......
18	870	842	631	162	80	77	......	32	24	33	......
19	420	842	631	140	74	80	......	26	22	32	......
20	372	709	631	119	77	74	......	24	24	25	......
21	324	631	631	104	79	66	......	22	24	22	......
22	324	631	566	99	109	62	......	24	22	16.7	......
23	324	631	566	94	106	50	......	24	17.6	16.7	......
24	324	631	516	86	95	53	......	24	17.1	16.7	......
25	324	631	516	83	94	53	......	22	17.1	16.7	......
26	282	566	516	83	86	49	......	19.1	16.7	15.8	......
27	237	566	516	83	80	47	......	17.1	15.8	14.8	......
28	237	566	468	80	74	46	......	15.8	14.8	14.8	......
29	237	516	468	70	69	38	......	14.8	15.8	11.8	......
30	237	468	420	63	66	37	......	13.9	14.8	12.4	......
31	237	468	......	57	63	......	......	13.0	14.8	......	......
Mean	502	911	487	149	92.2	57.4	42.3	37.9	30.4	18.1	13.2
Mean per square mile	0.158	0.286	0.153	0.181	0.111	0.070	0.051	0.201	0.161	0.096	0.070
Run-off (depth in inches on drainage area)	0.13	0.33	0.17	0.17	0.13	0.08	0.006	0.19	0.18	0.11	0.008

[a] The discharges at these stations are fairly well defined for all stages.

Daily discharge, in second-feet, of Walker Fork, Wade Creek, and Forty-five Pup for 1910.

Day.	Walker Fork above Twelvemile Creek [a] (drainage area, 70.2 square miles).		Wade Creek at claim "No. 10 above" [b] (drainage area, 23.1 square miles).			Forty-five Pup at claim No. 13 [c] (drainage area, 9.1 square miles).		
	July.	Aug.	July.	Aug.	Sept.	July.	Aug.	Sept.
1	....	30	....	2.0	11.0	....	0.7	1.7
2	....	15.0	....	1.1	13.4	....	.6	2.3
3	33	11.3	....	1.1	13.4	....	.6	2.3
4	30	11.3	2.1	1.1	13.4	....	.6	1.7
5	27	10.0	5.5	1.7	12.2	....	.6	1.3
6	51	8.7	8.8	1.1	16.4	....	.6	1.3
7	37	10	7.4	1.7	13.4	....	.6	1.3
8	26	54	6.0	31	11.0	....	13.2	1.3
9	23	242	4.5	125	11.0	....	63	1.3
10	26	114	3.0	90	13.4	....	16.6	1.3
11	30	61	6.5	11.0	13.4	1.4	9.1	1.3
12	26	41	10.0	16.4	12.2	2.2	5.4	1.3
13	46	33	13.0	11.0	11.0	3.1	4.5	....
14	33	26	16.4	12.2	16.4	2.4	3.7	....
15	41	20	5.0	8.8	16.4	1.9	2.9	....
16	26	25	10.0	27	13.4	1.4	3.7	....
17	23	30	7.5	23	19.5	1.9	2.9	....
18	23	30	9.0	19.5	16.4	1.4	2.3	....
19	26	26	5.2	19.5	16.4	1.0	2.3	....
20	15.0	26	1.5	13.4	13.4	.7	2.3	....
21	20	26	4.0	13.4	11.0	.8	2.3	....
22	30	26	6.5	16.4	11.0	2.3	1.7	....
23	33	30	9.0	8.8	13.4	1.7	1.3	....
24	37	30	7.0	13.4	11.0	1.3	1.7	....
25	26	26	5.2	40	8.8	1.0	1.7	....
26	20	26	3.5	23	16.4	.8	1.3	....
27	15.0	....	1.7	27	13.4	.8	2.3	....
28	13.2	....	2.5	23	13.4	.7	1.7	....
29	26	....	3.2	13.4	8.8	.7	1.3	....
30	30	....	4.0	13.4	8.8	.6	1.3	....
31	30	....	3.0	11.0	....	.6	1.7	....
Mean	28.4	38.0	6.11	20.0	13.1	1.37	4.98	1.53
Mean per square mile	0.405	0.541	0.264	0.866	0.567	0.151	0.547	0.168
Run-off (depth in inches on drainage area)	0.44	0.52	0.27	1.00	0.63	0.12	0.63	0.07

[a] The rating curve for this station is fairly well defined below 50 second-feet discharge; above that point it is only approximate.

[b] Discharges at this station from July 7 to 13 and 14 to 26 and July 28 to Aug. 1 were determined from comparative hydrographs and are only approximate. The rating curve is fairly well defined below 25 second-feet discharge.

[c] The discharges given for this station below 20 second-feet are probably correct within 10 per cent.

Daily discharge, in second-feet, of Buckskin Creek above Forty-five Pup for 1910.

[Drainage area, 33 square miles.]

July 11	4.3	Sept. 1	5.3
July 13	4.8	Sept. 4	4.3
July 14	4.3	Sept. 5	3.9
Aug. 4	3.3	Sept. 13	3.9
Aug. 5	2.9		
Aug. 11	12.4	Mean	4.88
Aug. 21	4.3		

Miscellaneous measurements in South Fork of Fortymile River drainage basin in 1910.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
Aug. 7	Gold Creek above Willow Creek	57.7	2.0	0.03
Aug. 12	Gold Creek 1 mile above mouth	112	21	.19
July 2	Walker Fork above Poker Creek	7.4	5.7	.77
Do	Poker Creek one-half mile above mouth	3.1	1.3	.42
Do	Davis Creek 1 mile above mouth	1.5	1.5	1.00
July 5	Napoleon Creek at mouth	13.3	1.1	.08

NORTH FORK OF FORTYMILE RIVER DRAINAGE BASIN.

The North Fork drains a large area north and west of the main stream, rising in irregular ridges to heights of 3,000 to 6,000 feet. Near the headwaters the valleys are broad with gentle slopes, but nearer the mouth they become canyon-like, with prominent benches, which are merely continuations of those already mentioned in connection with Fortymile River. The drainage area is 2,120 square miles.

The principal tributaries from head to mouth are Comet and Champion creeks from the east, and Slate Creek, Middle Fork, Bullion and Hutchinson creeks from the west. The drainage area of the Middle Fork is 1,110 square miles, which is 52 per cent of the total drainage of the North Fork. Its headwaters drain a flat basin-like country smaller than but similar to that of Mosquito and Dennison forks.

About 3 miles below the mouth of Hutchinson Creek the river originally followed a large meander locally known as the "kink." Although the distance around was 2¾ miles, the two channels at the neck of the meander were separated by a sharp rock ridge only about 100 feet high and about the same distance in width at the water level. Several years ago a channel was blasted through the rock ridge to divert the water and thus drain the meander for mining purposes. A fall of about 17 feet is now concentrated in a horizontal distance of only a little over 100 feet, which gives possibilities for development of considerable water power. (See horsepower table, p. 180.)

Daily discharge, in second-feet, of North Fork and Hutchinson and Montana creeks for 1910.

Day.	North Fork of Fortymile River above Middle Fork [a] (drainage area, 724 square miles).				North Fork of Fortymile River at "kink" [b] (drainage area, 2,010 square miles).			Hutchinson Creek below Montana Creek [c] (drainage area, 29.0 square miles).		Montana Creek at claim No. 7 (drainage area, 5.9 square miles).		
	July.	Aug.	Sept.	Oct.	July.	Aug.	Sept.	July.	Aug.	July.	Aug.	Sept.
1	......	162	135	189	......	293	352	......	4.5	......	0.5	1.1
2	......	162	204	162	......	300	340	......	4.1	......	.5	1.1
3	......	149	739	......	......	306	305	......	4.1	......	.5	1.1
4	......	135	610	......	......	306	564	......	4.1	......	.5	1.1
5	......	125	516	......	......	289	762	......	3.7	......	.5	1.5
6	......	106	610	......	......	286	762	......	3.7	......	.5	1.5
7	......	99	516	......	......	276	829	......	3.7	......	.5	1.5
8	......	189	516	......	......	263	777	......	73	......	19.4	1.5
9	......	1,430	464	......	396	1,740	629	......	88	......	25	1.2
10	......	923	377	......	1,150	2,350	540	......	78	......	7.0	1.2
11	......	610	377	......	1,110	1,750	525	......	69	......	4.3	1.2
12	......	464	330	......	1,120	1,250	525	......	51	......	3.6	1.1
13	......	330	330	......	1,020	918	488	......	51	......	2.8	1.1
14	......	256	292	......	1,040	858	416	10.5	51	1.2	2.4	1.1
15	256	219	665	......	702	653	431	8.6	51	1.1	2.1	1.1
16	230	204	1,210	......	585	482	1,630	6.7	51	1.1	2.2	1.1
17	189	219	981	......	435	384	1,890	6.1	44	.8	2.2	1.1
18	162	204	1,210	......	[d]443	480	2,080	5.4	37	.8	2.2	1.1
19	189	219	872	......	451	450	1,670	5.0	30	.7	2.2	1.1
20	189	219	665	......	429	548	1,340	4.8	23	.5	2.2	2.6
21	162	204	464	......	411	732	836	6.7	16	.5	2.2	2.2
22	162	189	419	......	300	687	713	6.7	8.2	.5	1.5	2.2
23	219	162	374	......	306	510	543	7.0	9.2	.5	1.5	......
24	204	155	330	......	321	428	......	6.1	10.2	.7	1.5	......
25	219	162	256	......	332	414	......	4.8	11.2	.5	1.2	......
26	162	155	256	......	442	528	......	4.5	12.2	.5	1.2	......
27	149	162	219	......	406	506	......	4.5	13.2	.5	1.2	......
28	149	189	189	......	347	477	......	4.5	14.2	.5	1.2	......
29	125	182	162	......	329	491	......	4.5	15.2	.5	1.1	......
30	116	162	189	......	291	527	......	4.7	......	.5	1.1	......
31	135	135	......	......	254	408	......	4.8	......	.5	1.1	......
Mean	177	267	483	176	549	642	824	5.88	28.8	0.661	3.09	1.35
Mean per square mile	0.244	0.369	0.667	0.243	0.273	0.319	0.410	0.203	0.993	0.112	0.524	0.229
Run-off (depth in inches on drainage area)	0.15	0.42	0.74	0.02	0.23	0.37	0.35	0.14	1.07	0.07	0.60	0.19

[a] The rating curve for this station is well defined below 400 second-feet discharge.

[b] Drainage area of the North Fork at the "kink" is 74 per cent of that of the Fortymile at Steele Creek minus that of the South Fork at Franklin Creek. Daily discharges at the "kink" were obtained by taking 74 percent of the difference in discharge between the Fortymile at Steele Creek and the South Fork at Franklin Creek.

[c] The discharges at this station for Aug. 13-15, 17-21, and 23-28 were determined by comparative hydrographs and interpolation.

[d] Mean of the 17th and 19th.

Miscellaneous measurements in North Fork of Fortymile River drainage basin in 1910.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	Sec.-ft.	Sec.-ft.
July 18	North Fork of Fortymile River above Slate Creek.	109	16.8	0.15
July 15	North Fork of Fortymile River at "kink"	2,010	897	.45
Aug. 8	....do	2,010	425	.21
July 18	Slate Creek at mouth	336	40	.12
Aug. 26	Champion Creek below Arkansas Creek	43.4	8.8	.20
Sept. 11	....do	43.4	13.8	.32
Aug. 25	Champion Creek above Bear Creek	125	14.1	.11
July 17	Champion Creek at mouth	179	78	.44
Aug. 25	Bear Creek at mouth	48.0	9.0	.19
July 16	Middle Fork of Fortymile River at mouth	1,110	397	.36
Aug. 22	Bullion Creek at mouth	34.3	14.6	.43
July 13	Hutchinson Creek below Confederate Creek	16.6	7.3	.44
July 14	....do	16.6	5.8	.35
Aug. 7	....do	16.6	1.7	.10
Aug. 9	....do	16.6	35	2.11
Aug. 21	....do	16.6	3.9	.23

EAGLE DISTRICT.

LOCATION OF AREA.

The Eagle district in this report is considered as the area drained by Mission Creek and its tributaries. It lies in the Eagle precinct and the town of Eagle is the center of commercial activity. It was topographically surveyed in 1898 and is covered by the map of the Fortymile quadrangle.

GAGING STATIONS AND MEASURING POINTS.

The following list gives the locations at which gaging stations were maintained or discharge measurements made in 1910 in the Eagle district:

Gaging stations and measuring points in Eagle district, 1910.

Mission Creek drainage basin:
- Mission Creek above Colorado Creek.
- Mission Creek above American Creek.
- Excelsior Creek at mouth.
- American Creek at claim "No. 8 above."
- American Creek at United States pumping plant.
- Discovery Fork of American Creek below Star Gulch.

MISSION CREEK DRAINAGE BASIN.

Mission Creek drains a circular-shaped area of 170 square miles lying between Fortymile and Seventymile rivers. It enters the Yukon at the town of Eagle and has a length of about 30 miles. It flows generally northeastward to Excelsior Creek, where it makes a sharp turn and takes a southeastward course for 8 miles to its mouth. Its most southern waters rise at an elevation of about 4,000 feet in the divide at the head of O'Brien Creek, and its two largest tributaries from the west, Seward and Excelsior creeks, drain a portion of the eastern slope of Glacier Mountain, which reaches an elevation of 6,000 feet. Above Excelsior Creek the valley is bordered by high, precipitous slopes on either side. Below the big bend to the east the stream channel follows closely the northern part of the valley, which has a steep and narrow drainage slope to the north, whereas on the south the slope to the summit of the divide is very gradual.

American Creek is the largest tributary of Mission Creek and joins it from the south about a mile from the Yukon. It flows northeastward and is about 18 miles in length. Discovery Fork is its chief branch and enters American Creek about 8 miles from the head. Above Marion Creek, which is a small feeder from the east, the valley is sharply V-shaped and in some portions is almost canyon-like, being inclosed on either side by barren rocky slopes. Below Marion Creek the valley gradually broadens until it finally loses its identity in the Mission Creek Flats. The average grade through that portion in which mining has been carried on is about 125 feet to the mile. The total fall from the head to the mouth is about 2,000 feet.

Wolf Creek is tributary from the south about halfway between American and Excelsior creeks.

Spruce is the prevailing timber. An abundant supply is available for fuel, and in the Mission Creek valley considerable quantities of a size suitable for saw logs are to be found.

Daily discharge, in second-feet, of Mission Creek and Discovery Fork of American Creek for 1910.

Day.	Mission Creek above Colorado Creek [a] (drainage area, 84.81 square miles).			Discovery Fork of American Creek below Star Gulch [b] (drainage area, 14.8 square miles).			
	June.	July.	Aug.	June.	July.	Aug.	Sept.
1	......	239	70	......	2.7	1.0	2.7
2	......	93	56	......	1.5	1.0	36
3	......	70	48	......	1.2	2.0	24
4	......	70	42	......	1.2	3.0	12.4
5	......	251	42	......	1.2	6.0	12.4
6	......	70	38	......	1.2	10.0	10.4
7	......	56	......	......	.9	14.6	8.4
8	......	48	......	......	.9	44	6.3
9	......	48	......	......	.9	12.4	10.2
10	......	42	......	......	.8	10.0	8.4
11	......	42	......	......	2.7	8.0	8.4
12	......	93	......	......	73	6.0	6.3
13	......	84	......	......	24	4.0	8.0
14	......	56	......	......	10.2	3.8	12.4
15	......	42	......	......	2.7	3.2	12.4
16	......	48	......	......	2.7	3.8	14.6
17	......	48	......	......	1.5	3.8	21
18	......	42	......	......	1.5	4.3	12.4
19	......	42	......	......	2.7	4.2	11.2
20	......	42	......	......	1.5	4.2	10.2
21	......	48	......	......	1.5	4.1	9.0
22	......	62	......	......	1.5	4.1	7.5
23	......	56	......	......	1.5	4.0	6.3
24	......	48	......	......	1.5	4.0	6.3
25	111	42	......	......	1.5	3.9	6.7
26	102	42	......	......	1.5	3.8	7.1
27	102	42	......	2.7	1.5	3.2	......
28	124	38	......	10.2	.8	3.2	......
29	144	38	......	40	.8	3.0	......
30	124	35	......	10.2	.8	3.0	......
31	......	84	......	......	.8	2.8	......
Mean	118	66.5	49.3	15.8	4.80	6.08	11.2
Mean per square mile	1.39	0.784	0.581	1.07	0.324	0.411	0.757
Run-off (depth in inches on drainage area)	0.31	0.90	0.13	0.16	0.37	0.47	0.73

[a] The discharges at this station are fairly well defined between 50 and 110 second-feet.
[b] The rating curve for this station is well defined below 25 second-feet. A considerable part of the discharges during August were determined by comparative hydrographs, but the figures given are probably correct within 10 per cent.

Daily discharge, in second-feet, of American Creek for 1910.

Day.	American Creek at claim "No. 8 above" (drainage area, 24.1 square miles).				American Creek at United States pumping plant (drainage area, 67.3 square miles).				
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	Oct.
1	......	19.4	8.0	7.7	......	24	22	22	36
2	......	12.6	7.7	36	......	45	22	57	36
3	......	12.6	7.4	25	......	34	22	146	22
4	......	10.4	7.1	14.6	......	24	15.0	87	22
5	......	[a]145	6.8	12.6	......	75	11.2	57	22
6	......	36	6.5	11.4	......	45	13.1	57	22
7	......	17.0	6.2	10.1	......	24	13.1	50	22
8	......	12.6	31	8.9	......	22	30	42	22
9	......	10.4	36	13.0	......	22	[a]541	42	30
10	......	8.9	[a]84	19.4	......	15.0	87	50	22
11	......	14.6	71	14.6	......	15.0	75	50	22
12	......	17.0	54	8.9	......	30	57	42	22
13	......	10.4	17.0	11.6	......	42	50	42	22
14	......	8.9	12.6	14.6	45	42	50	50	......
15	......	7.7	8.9	42	42	42	26	165	......
16	......	7.7	8.9	44	50	32	30	114	......
17	......	7.7	8.9	44	[1]779	22	30	99	......
18	......	7.7	8.9	30	208	42	30	122	......
19	......	8.9	8.9	17.0	99	42	26	87	......
20	......	7.7	8.9	17.0	75	22	42	50	......
21	......	7.7	8.9	17.0	57	22	32	42	......
22	......	7.7	8.9	......	42	22	36	42	......
23	......	7.7	8.9	......	42	42	36	42	......
24	......	7.7	8.9	......	34	30	26	42	......
25	......	7.7	8.9	......	30	22	26	42	......
26	12.6	7.2	8.9	......	24	30	30	42	......
27	12.6	6.7	8.9	......	24	15.0	30	42	......
28	12.6	6.2	6.9	......	22	15.0	30	30	......
29	10.4	5.7	4.9	......	26	15.0	26	30	......
30	54	5.7	4.5	......	30	15.0	22	36	......
31	......	8.3	4.2	......	......	15.0	22	......	......
Mean	20.4	14.9	15.9	20.0	95.8	29.2	48.7	60.7	24.8
Mean per square mile	0.846	0.618	0.660	0.830	1.42	0.434	0.724	0.902	0.368
Run-off (depth in inches on drainage area)	0.16	0.71	0.76	0.65	0.90	0.50	0.83	1.01	0.18

[a] These discharges are only approximate.

Miscellaneous measurements in Mission Creek drainage basin in 1910.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Second-feet.*	*Second-feet.*
June 13	Mission Creek above American Creek	168	225	1.34
June 23	Excelsior Creek at mouth	31.1	33	1.06
Aug. 29	....do	31.1	23	.74
Sept. 8	....do	31.1	43	1.38
Aug. 29	Wolf Creek at road crossing	28.4	12.0	.42
Sept. 8	....do	28.4	20	.70

SEVENTYMILE DISTRICT.

LOCATION OF AREA.

The Seventymile district includes the area drained by Seventymile River and that lying to the north of the Seventymile and south of the Yukon. This district lies entirely within the Eagle precinct, and Eagle is the supply point for the mines. The maps showing the area are those of the Fortymile and Circle quadrangles.

GAGING STATIONS AND MEASURING POINTS.

The following list gives the locations at which gaging stations were maintained or discharge measurements made in 1910 in the Seventymile district:

Gaging stations and measuring points in Seventymile district, 1910.

- Seventymile River drainage basin:
  - Seventymile River above Flume Creek.
  - Seventymile River at the falls.
  - Flume Creek one-fourth mile above mouth.
  - Flume Creek ditch near outlet.
  - Alder Creek at claim "No. 7 above."
  - Deep Creek at mouth.
  - Nugget Creek at mouth.
  - Granite Creek above forks.
  - Granite Creek below forks.
  - Barney Creek at ditch intake.
  - Barney Creek at mouth.
  - Sonickson Creek at ditch intake.
  - Sonickson Creek ditch at outlet.
  - Mogul Creek at mouth.
  - Crooked Creek below Eldorado Creek.
  - Bryant Creek 2 miles above mouth.
- Washington Creek drainage basin:
  - Washington Creek below forks.

SEVENTYMILE RIVER DRAINAGE BASIN.

Seventymile River has its source in a relatively high and rugged divide east of Charley River. It flows east for about 60 miles to a point 4 miles from its mouth, where it makes a right-angle turn and flows north, joining Yukon River about 20 miles below Eagle. The drainage area is 667 square miles and is extremely unsymmetrical with respect to the river valley, as over three-fourths of it lies to the south.

The principal tributaries from the south, beginning with the headwaters, are Diamond Fork, Flume, Alder, Granite, Green, Sonickson, Mogul, and Bryant creeks. From the north Barney, Washington, and Crooked creeks are the principal streams, although much smaller than those from the south.

Extensive bench formations occur throughout the Seventymile Valley. Above the falls, which are located about one-half mile below Washington Creek, the river flows through a rather broad gravelly flood plain, but below the falls it is more closely confined and along a considerable part of its course has cut a rock canyon 20 to 30 feet deep. At the falls the river has a drop of about 9 feet in a horizontal distance of less than 200 feet. From Diamond Fork to the mouth, a distance of 53 miles following the general trend of the valley, the river has a fall of over 2,000 feet. From Diamond Fork to Barney Creek the river falls 1,400 feet in 25 miles and from Flume Creek to Barney Creek there is a drop of 600 feet in 15 miles.

Daily discharge, in second-feet, of Seventymile River for 1910.

Day.	Seventymile River above Flume Creek (drainage area, 129 square miles).[a]					Seventymile River at the falls (drainage area, 465 square miles).[b]			
	June.	July.	Aug.	Sept.	Oct.	June.	July.	Aug.	Sept.
1	......	108	518	108	70	......	322	602	275
2	......	137	272	412	68	......	400	548	760
3	......	102	152	325	......	......	258	360	1,020
4	......	100	124	298	......	......	380	290	938
5	......	278	108	314	......	......	520	270	830
6	......	124	89	257	......	......	322	225	865
7	......	96	2,280	247	......	......	465	208	830
8	......	74	1,390	186	......	......	208	4,300	575
9	......	60	481	179	......	......	210	4,430	575
10	......	108	446	205	......	......	300	1,550	695
11	......	555	288	179	......	......	650	865	575
12	......	674	205	146	......	......	1,100	586	520
13	......	383	168	146	......	......	1,350	975	465
14	......	186	186	239	......	......	380	680	619
15	......	137	152	503	......	......	305	380	1,600
16	......	117	168	402	......	662	340	434	1,230
17	......	100	168	325	......	2,120	262	420	1,060
18	......	137	247	247	......	2,250	290	492	865
19	278	205	272	186	......	938	420	630	662
20	341	112	186	137	......	1,020	290	465	520
21	267	92	137	132	......	695	262	400	440
22	247	122	112	128	......	760	380	340	360
23	288	104	102	124	......	830	305	275	360
24	183	124	98	122	......	575	305	275	368
25	183	102	92	102	......	400	290	262	380
26	162	100	108	92	......	400	262	270	360
27	122	76	112	84	......	340	222	360	360
28	159	74	124	70	......	830	208	456	230
29	156	76	104	82	......	520	250	340	225
30	112	76	106	70	......	420	223	305	225
31	......	518	92	......	......	......	975	281	......
Mean	208	170	293	202	69	851	402	719	626
Mean per square mile	1.61	1.32	2.27	1.57	0.535	1.83	0.865	1.55	1.35
Run-off (depth in inches on drainage area).	0.72	1.52	2.62	1.75	0.04	1.02	1.00	1.79	1.51

[a] Discharges at this station above 400 second-feet are only approximate.
[b] Discharges at this station above 1,500 second-feet are only approximate.

Daily discharge, in second-feet, of Flume and Alder creeks for 1910.

Day.	Flume Creek ¼ mile above mouth (drainage area, 36.7 square miles).[a]				Alder Creek at claim "No. 7 above" (drainage area, 11.8 square miles).[b]				
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	Oct.
1	......	22	86	21	......	9.8	15.2	8.2	7.7
2	......	26	50	40	......	9.8	11.5	14.0	7.1
3	......	19.6	34	66	......	9.2	10.6	24	7.7
4	......	17.9	27	63	......	15.2	9.2	25	7.3
5	......	38	23	61	......	12.9	9.2	31	6.7
6	......	28	18.7	56	......	10.6	8.2	29	......
7	......	22	16.4	44	......	9.8	8.2	18.5	......
8	......	16.5	192	39	......	9.2	45	15.2	......
9	......	17.3	181	35	......	9.2	70	11.5	......
10	......	13.9	106	42	......	8.8	56	17.0	......
11	......	14.3	63	42	......	9.8	33	12.9	......
12	......	113	54	32	......	9.8	18.5	12.1	......
13	......	26	42	30	......	9.8	12.9	11.5	......
14	......	15.8	36	37	......	9.2	10.6	14.0	......
15	......	20	37	97	......	9.2	10.6	56	......
16	......	42	39	83	......	9.2	10.6	42	......
17	......	30	37	67	......	8.8	10.6	27	......
18	......	49	37	55	......	12.1	10.6	20	......
19	67	56	42	45	......	12.9	9.8	12.9	......
20	86	37	35	38	24	9.8	9.2	9.2	......
21	65	28	26	34	12.9	11.5	9.2	10.6	......
22	69	28	19.4	31	14.0	10.6	9.2	8.2	......
23	68	22	18.5	28	12.9	9.8	8.8	7.3	......
24	47	18.9	16.7	25	11.5	9.8	8.2	7.3	......
25	26	18.5	15.6	23	11.5	9.8	8.2	7.3	......
26	34	16.9	17.1	23	10.6	9.8	8.2	7.3	......
27	28	15.5	18.6	22	10.6	8.8	8.2	7.3	......
28	53	14.3	17.0	......	12.1	9.2	9.8	7.9	......
29	40	16.9	17.1	......	9.8	8.2	9.2	8.5	......
30	28	19.4	24	......	9.2	8.8	9.2	9.2	......
31	......	115	21	......	......	32	8.2	......	......
Mean	50.9	30.2	44.1	43.7	12.6	10.8	15.4	16.4	7.3
Mean per square mile	1.39	0.823	1.20	1.19	1.07	0 915	1.31	1.39	0.619
Run-off (depth in inches on drainage area)	0.62	0.95	1.38	1.19	0.44	1.05	1.51	1.55	0.12

[a] The rating curve for this station is well defined below 100 second-feet discharge previous to Aug. 7; after that date it may be slightly in error, due to shifting channel conditions.

[b] The discharges given at this station are probably correct within 10 per cent for all those below 40 second-feet.

Daily discharge, in second-feet, of Barney, Sonickson, and Crooked creeks for 1910.

Day.	Barney Creek above ditch intake.[a]				Sonickson Creek above ditch intake (drainage area, 12.6 square miles).[b]				Crooked Creek below Eldorado Creek (drainage area, 17.2 square miles).			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1	......	0.6	0.8	1.1	......	4.0	6.2	10.2	......	4.4	1.9	4.4
2	......	.6	.7	4.1	......	3.7	5.8	30	......	3.4	1.9	16.0
3	......	.6	.6	7.1	......	3.3	5.4	51	......	2.6	1.4	29
4	......	.6	.5	6.7	......	3.0	5.0	42	......	3.4	1.4	22
5	......	2.8	.4	6.2	......	2.9	4.5	34	......	4.4	1.0	22
6	......	1.2	.4	5.7	......	2.8	4.0	30	......	3.4	1.0	20
7	......	1.0	1.0	5.2	......	2.7	5.5	26	......	2.6	1.0	14.0
8	......	.8	3.5	4.7	......	2.5	7.0	26	......	1.9	c139	8.4
9	......	.6	13.4	4.2	......	2.5	192	26	......	1.4	c119	12.0
10	......	.6	11.7	3.7	......	2.5	55	24	......	1.4	28	18.0
11	......	.6	3.7	......	......	3.2	34	21	......	1.9	18.0	16.0
12	......	.7	1.8	......	......	3.9	17.7	19	......	3.4	10.2	12.0
13	......	.8	1.8	......	......	4.6	13.0	17.7	......	2.6	7.0	12.0
14	......	.9	1.5	......	......	5.3	11.2	20	......	1.9	5.5	25
15	......	.8	1.2	......	......	5.0	10.7	26	3.4	1.9	5.5	46
16	......	.6	.9	......	8.8	4.5	10.2	32	5.5	1.4	7.0	28
17	......	.6	1.2	......	310	4.0	10.2	39	43	1.4	7.0	34
18	2.8	.6	1.5	......	61	4.6	10.6	......	28	1.9	12.0	25
19	2.0	.6	1.8	......	20	10.2	10.0	......	14.0	2.6	10.2	20
20	.9	.4	1.5	......	17.7	7.9	9.5	......	8.4	1.9	8.4	25
21	.9	.5	1.2	......	9.5	6.2	8.7	......	7.0	1.9	7.0	......
22	.6	.6	.9	......	9.5	12.8	7.9	......	4.4	4.4	5.5	......
23	.5	.6	.9	......	8.4	19.3	7.2	......	4.4	3.4	5.5	......
24	.4	.6	.9	......	6.2	13.9	8.4	......	3.5	4.4	5.5	......
25	.4	.6	.9	......	5.3	12.8	8.4	......	2.6	3.4	5.5	......
26	.5	.6	.9	......	4.9	6.2	8.4	......	2.6	2.6	5.5	......
27	.6	.6	.9	......	6.8	5.8	9.0	......	7.0	1.9	5.5	......
28	1.2	.6	.9	......	5.7	5.4	10.1	......	7.0	1.4	5.5	......
29	1.2	.7	.9	......	4.6	5.0	11.2	......	7.0	1.4	4.4	......
30	1.2	.8	.9	......	4.3	5.4	9.5	......	8.4	1.4	4.4	......
31	......	.9	.9	......	......	5.9	9.8	......	......	1.9	4.4	......
Mean	1.02	0.745	1.94	4.87	32.2	5.86	17.0	27.9	9.76	2.51	14.4	20.4
Mean per square mile	......	......	......	......	2.56	0.465	1.35	2.21	0.567	0.146	0.837	1.19
Run-off (depth in inches on drainage area)	......	......	......	......	1.43	0.536	1.56	1.40	0.34	0.17	0.96	0.88

[a] The discharges at this station are based on gage readings taken about every 4 days and are only approximate, owing to shifting channel conditions.
[b] The discharges at this station for July 9-13 and 25-28, Aug. 2-5, and several shorter periods are estimated from comparative hydrographs. The rating curve is well defined below 80 second-feet.
[c] Approximate.

Miscellaneous measurements in Seventymile River drainage basin in 1910.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
June 20	Flume Creek ditch near outlet	....	2.6	....
July 20	....do	....	2.5	....
Sept. 5	....do	....	3.5	....
June 21	Deep Creek at mouth	4.8	3.1	0.65
Do	Nugget Creek at mouth	2.7	.47	.17
July 18	Granite Creek above forks	68.1	10.4	.15
Do	Granite Creek below forks	112	22	.20
June 18	Barney Creek at mouth	....	4.3	....
June 22	Sonickson Creek ditch at outlet	....	2.8	....
June 16	Mogul Creek at mouth	64.4	79	1.23
Aug. 30	....do	64.4	47	.73
June 15	Bryant Creek 2 miles above mouth	21.4	21	.98
Aug. 29	....do	21.4	27	1.26
Sept. 8	....do	21.4	19.2	.90

WASHINGTON CREEK DRAINAGE BASIN.

Washington Creek rises in the divide north of the Seventymile and flows northward for about 25 miles to its junction with the Yukon. At the head the basin is about 18 miles wide and is drained by several large tributaries which reach from Barney Creek on the east to a point about opposite Flume Creek on the west. Ten miles below the head the basin is abruptly contracted to a width of about 6 miles and it averages about that width to the mouth. The headwaters flow through broad valleys, which have gentle slopes rising to a uniform altitude of about 3,000 feet. The drainage area above the mouth is 190 square miles.

Just below the junction of two small feeders, which form the headwaters of the main stream and rise in the divide at the west of Barney Creek, a measurement was made August 31 to determine the quantity of water on that day available for diversion over the divide to be used for hydraulicking on Pleasant Creek, which is a small stream entering Seventymile River from the north just above Barney Creek. No accurate survey had been made, and it is doubtful if water could be carried over the divide in a ditch with the intake below the forks. It was difficult to obtain an accurate measurement because the stream flows through a flat, swampy area in a deep-cut channel with overhanging muck banks. A discharge of 0.78 second-foot was recorded.

MINERAL RESOURCES OF THE BONNIFIELD REGION.

By Stephen R. Capps.

INTRODUCTION.

The region covered by this report lies on the north slope of the Alaska Range between Nenana and Delta rivers, and in a general way is limited on the south by the crest of the range and on the north by the Tanana Flats. It therefore forms a belt about 30 miles wide and 110 miles long, extending from Nenana River eastward to the Delta. That portion between Nenana and Little Delta rivers has been widely known as the Bonnifield region, which is here considered to extend eastward to Delta River. Since the establishment of Fairbanks as an important mining camp the area south of the Tanana has been visited by large numbers of prospectors, and although no strikes of exceptional richness have been made placer gold is widely distributed and has been found in paying quantities on a number of creeks. Further attention has been attracted to this region by the extensive fields of lignite, by reports of large bodies of low-grade gold-bearing ore, and by the possibilities of profitably developing some of the great gravel benches which carry a low content of placer gold.

The western border of this area was visited in 1902 by Alfred H. Brooks [1] and L. M. Prindle, the results of their work being embodied in a report now in press. In 1906 Prindle again visited that part of the area lying between Nenana and Wood rivers, and a brief account of his work has been published.[2] The notes, traverses, and manuscript of both of these investigators have been freely drawn upon by the present writer, who has also been greatly aided by them in personal conferences in the office. The organization of the field party and its itinerary are discussed on page 11 of this volume.

GENERAL DESCRIPTION OF THE REGION.

GEOGRAPHIC FEATURES.

The region bounded by Nenana, Tanana, and Delta rivers may be divided into three distinct east-west belts of different topographic character. On the north the Tanana Flats extend from Tanana River to the foothills. As Tanana River makes a broad loop north-

[1] Brooks, A. H., and Prindle, L. M., The Mount McKinley region, Alaska: Prof. Paper U. S. Geol. Survey No. 70, 1911.

[2] Prindle, L. M., Bull. U. S. Geol. Survey No. 314, 1907, pp. 205-226.

ward between the mouths of Nenana and Delta rivers, this flat is of varying width, being about 30 miles wide along the Nenana, 50 miles south of Fairbanks, and 20 miles on the west side of Delta River. This great lowland area is of slight relief, broken only by a few isolated hills which rise above the general level of the plain. Most of it is heavily timbered with spruce, and the drainage is so poorly developed that numerous lakes and marshes make summer travel over the greater portion of it impossible. Along its southern edge the Tanana lowland ends abruptly, giving place to a belt of foothills which stretch southward from 15 to 20 miles beyond the flats. These hills form minor east-west ranges parallel to the higher mountains to the south and have for the most part rounded summits and long connecting ridges of smooth outlines, ranging in elevation from 2,500 to 3,500 feet, although here and there hills with somewhat sharper peaks rise to heights of 4,000 or 5,000 feet. Between the ranges of hills there are in places broad structural valleys. The third belt comprises the rugged mountains of the Alaska Range, which here trends nearly east and west, and though not so high as that part west of the Nenana its loftier peaks are snow covered and support vigorous glaciers. The highest peak in this region, Mount Hayes, with an altitude of 13,800 feet, is a conspicuous landmark through much of the Tanana country. (See Pl. X.)

The drainage throughout the region is tributary to the Tanana. The larger streams rising in the higher ranges and flowing southward cut transversely across the foothill ranges, in many places with deep, narrow canyons, but many of the streams from the foothills follow the east-west transverse valleys to join the larger north-south streams. The most important streams of the area, from west to east, are Nenana River, Totatlanika and Tatlanika creeks, Wood and Little Delta rivers, Delta Creek, and Delta River. Only those streams of considerable volume maintain definite channels to the Tanana, the smaller creeks being absorbed by the flats, which are drained by irregular swampy streams.

As supplies can be transported to the hills much more cheaply by sledding in the winter than by trail in summer, few trails have been built in this region. An old Indian trail from the Tanana up the Nenana has been cut out and widened, but numerous forest fires during the summer of 1910 were followed by the falling of the timber, and much of this trail is now obliterated. A trail from the mouth of Wood River to the diggings on Tatlanika and Gold King creeks is passable during the summer months, and a good winter road from Gold King Creek to Fairbanks has been chopped out. Another feasible route to Dry Creek and Wood River follows the military winter road from Washburn across the flats and then swings southwest over the bare ridges. A fourth route, but little used, leaves the

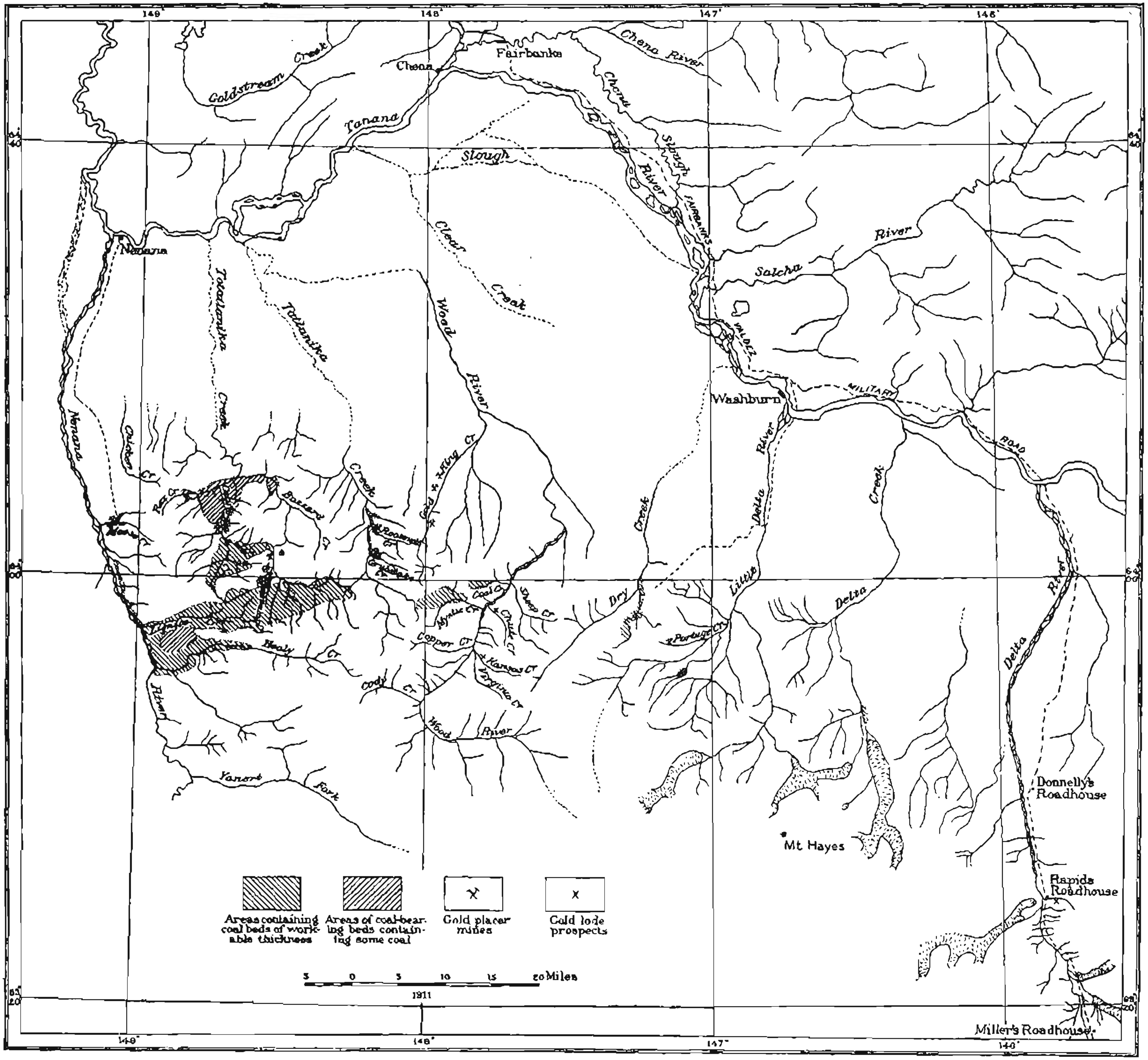
Valdez-Fairbanks road near Donnelly's and follows the low hills westward. Fairbanks and Tanana River points form the base of supplies for the region, and the greater part of the expense of freighting is usually incurred between the river and the creeks.

Horse feed is found nearly everywhere in the summer months, either along the stream valleys or in the heads of the small draws above timber, which commonly grows to an elevation of 2,000 to 2,500 feet.

GENERAL GEOLOGY.

The geologic formations represented in the region incluae an old schist series composed of metamorphosed sedimentary rocks and another schist series of metamorphic igneous rocks, both having been cut by large bodies of intrusives; much younger deposits of loosely cemented and somewhat folded beds; high bench gravels but little deformed; and more recent glacial and alluvial deposits. The old schists formed from metamorphosed sediments compose the greater part of the main range of mountains. They consist for the most part of quartz-mica schists with quartzites, cherts, and carbonaceous schists. Large bodies of granitic rocks have in places been intruded into these schists, and other varieties of igneous intrusives have been injected into and metamorphosed with the sediments in an intricate way. This series has been called the Birch Creek schist. The second schist series of altered igneous rocks forms the more important of the foothill ranges. It contains some sedimentary material, however, so that the two schist series in places show such intergradations that the boundaries are difficult to establish. Quartz-feldspar schists are the prevailing type, the rock being porphyritic over considerable areas, the feldspars occurring as conspicuous crystals with characteristic boundaries. These feldspars in places are over 2 inches in diameter, and many slopes are covered with crystals which have weathered out of the matrix.

Unconformably overlying the schists and occupying shallow warped basins between schist ridges are areas of Tertiary sediments consisting of slightly cemented sands and clays and beds of lignitic coal. The coal-bearing series when first deposited doubtless covered a much wider area than it does now. It probably covered all or nearly all of the foothill belt and may even now underlie large areas of the Tanana Flats. The beds vary in attitude from a nearly horizontal position to dips approaching the vertical, but in general occupy basins in the schists, the coal series dipping away from the bordering schists toward the centers of the basins. Overlying the coal series is a thick deposit of gravels, which is evidently of considerably later age than the coal series but which locally seems to be structurally continuous with it. The gravels have a total thickness of at least 1,500 feet and are in general less folded and tilted than the



SKETCH MAP OF BONNIFIELD REGION.

coal beds. They, too, were formerly much more widespread than now, as is shown by the remnants of the beds and by scattered gravels over the tops of many of the foothill ranges. Still later in age than the high gravels are the glacial moraines and terraces and, latest of all, the extensive gravel deposits of the present streams.

MINERAL RESOURCES.

GOLD PLACERS.

GENERAL DESCRIPTION.

The locations in which placer gold in paying quantities has been found all lie in the foothill belt between the Tanana Flats and the high schist range to the south (See Pl. X.) Furthermore, the placers all occur in the valleys of the smaller streams which were either north of the area invaded by ice at the time of the maximum glaciation or which were themselves not occupied by glaciers. It may be that formerly there was a concentration of gold in the valleys of the main range, but if so this gold was removed by the ice and scattered throughout the moraine deposits, and postglacial erosion has been insufficient to reconcentrate it or to form new placers in its stead. Colors can be found in almost all the streams of the foothills, but gold in paying quantities has so far not been found between Little Delta and Delta rivers. The streams between Wood and Nenana rivers are peculiar in that in their northward course from the high mountains to the Tanana Flats they cross one or two, and one of them four, hard-rock ridges into which they have cut deep canyons with steep rock walls. Between the canyons the valleys widen out and have developed broad gravel floors. Wide areas in the foothill belt are occupied by high bench gravels, and scattered gravels on the crests of many of the schist ridges give strong evidence that the high gravels formerly covered all of this area north of the main range. All the workable placers have been found in the streams which have cut their valleys into these gravels or which drain areas formerly gravel covered. The high gravels have in many places been shown to carry a small amount of placer gold, and doubtless most of the present placer deposits have been derived from a reconcentration of the gold from these high gravels, although some gold may have been contained in the Tertiary beds and upon their erosion may have been reconcentrated along with that from the high gravels, and some may have been derived directly from the weathering of the schists.

With the exception of Moose Creek, a tributary of the Nenana, on which pay was first found in 1909, the list of producing creeks is much the same as it was when visited by Prindle in 1906, and the total number of men engaged in mining or prospecting is smaller than at that time. The creeks which were producing during the last season are Moose, Totatlanika and its tributaries (Homestake, California, and Rex), two tributaries to Tatlanika from the east (Grubstake and Roosevelt), Gold King, and Portage creeks.

MOOSE CREEK.

Moose Creek is a small tributary of the Nenana from the east, joining that river about 10 miles above the Tanana Flats. It heads in a rounded schist ridge which was once capped by high gravels, and some remnants of these gravels still remain. The stream in its upper course occupies a valley cut in the schists, then cuts through beds of the coal-bearing series, below which it emerges upon the gravelly flats of the Nenana. The first production of consequence from this creek was in 1909, when it was reported that 100 ounces of gold was recovered during the last three weeks of the season, the pay being taken from a gravel bench with schist bedrock. It seems probable that the gold is a reconcentration from the high gravels which once covered the schist but most of which have now been removed by erosion. Seven men are reported to have been mining on this creek during 1910.

TOTATLANIKA BASIN.

Totatlanika Creek.—Totatlanika Creek is a stream of considerable size which enters the Tanana Flats about 16 miles east of the Nenana. It drains a basin in the hills about 275 square miles in area. It is formed by the confluence of a number of creeks which head in the high schist ridge north of Healy Fork. Below their confluence the stream flows through a succession of rock canyons and broad, open areas, the floor being narrow and difficult to travel in the canyons on account of the swift current of the stream, the steep rocky walls against which the stream cuts on one side or the other, and the accumulations of large bowlders and coarse blocky talus from the walls above. In the more open spaces between the canyons the valley floor widens, having a breadth of several hundred feet in places, and is composed of cobbles, fine gravels, and sands. The more important tributaries which join the main stream are Homestake, Buzzard, and California creeks below its junction with Rex Creek.

During the last six years a large number of men, encouraged by colors which can be found in almost all parts of the valley, have prospected along this stream from its head to the mouth of the lower canyon, and most of it has been staked during this period. Especially in the canyons where the gravels are shallowest are to be seen numerous old prospect pits and cuts. During 1910 all attempts to work ground on this stream had been abandoned except on a single claim, 2 miles below the mouth of Homestake Creek, where five men were engaged in mining. It is reported that the ground worked was yielding considerably more than wages.

There is abundant water for mining throughout this valley. In fact, the labor required in building wing dams and bedrock drains makes prospecting expensive even in periods of moderate run-off, and in times of high water the control of the stream is a serious problem to the prospector.

Homestake Creek.—Homestake Creek is a small tributary of the Totatlanika from the southwest and joins that stream in its upper canyon. Owing to the custom common among prospectors of giving different names to different parts of the same stream, the lower portion of this tributary is called Homestake and the upper portion Platt Creek. It heads in a broad, rolling depression bordered by schist ridges which extends between the Nenana and the head of Tatlanika Creek. This basin is underlain by unconsolidated beds of sands, clay, gravel, and lignite. Two miles below its source it leaves the open country to enter a narrow, steep-walled canyon through andesite mountains, broadening again somewhat before it joins the Totatlanika.

This valley has been prospected throughout its length, but workable placers have been found only in the canyon and in the open part of the valley just above it. Here mining has been in progress since 1906. The gravels are about 6 feet deep and lie on a decayed schist bedrock. The values occur in a well-defined pay streak 30 to 60 feet wide carrying reported values of about $3 to the cubic yard, the gold being found either on bedrock or in thin beds of oxidized yellowish gravels and sands. The ground being worked at the time of the writer's visit evidently received its gold from a small tributary which enters at that point. The gold is somewhat rusty and rather coarse, numerous pieces valued at $3 to $5 having been found. The greatest drawback to mining this ground is the scant water supply, less than a sluice head being available through the summer, so that it is necessary to hold the water with a dam until enough has accumulated to give a good volume for groundsluicing and to supply the sluice boxes.

In the canyon of Homestake Creek, below the mouth of a small tributary called Ptarmigan Creek, three men were engaged in mining, having been at work on this ground since 1906 with the exception of the season of 1908. Here the gravels average about 6 feet deep and lie on either a schist or an andesite bedrock. The values occur in a pay streak about 25 feet wide, and the gravels are reported to yield from $3 to $9 per square yard of bedrock. A sluice head or more of water is available for a season of about 80 days.

From the character of the gold and its distribution it seems probable that it has been derived from deposits of high gravels, most of which have now been removed by erosion.

It is estimated that the total production of Homestake and Platt creeks from 1906 to 1909, inclusive, has been about $50,000.

California Creek.—California Creek, which joins the Totatlanika at the head of its lower canyon, drains a considerable area in the vicinity of Jumbo Dome and has developed two canyons at points where it crosses schist ridges. Most of its course, however, is through a broad open country of rounded hills of gravels, sands, and lignite beds. Colors can be found in many parts of the basin of this stream, although no information was obtained of gold having been produced in commercial quantities. During the season of 1910 work was being done in but a single locality at the head of a canyon some 5 miles above the junction of California Creek with Rex Creek. Here two men had constructed a bedrock drain, in gravels about 6 feet deep lying upon a schist bedrock. At the time of visit the gold content of the gravels had not yet been determined, though panning tests seemed to show fair values.

Rex Creek.—Prospecting on Rex Creek has been carried on intermittently since 1905 by a number of men with but indifferent success. The creek, a tributary of the Totatlanika, heads in schist hills, some of which still have a portion of their ancient gravel capping. Some of its tributaries have sharp V-shaped valleys cut into the schist, but the valley of the main stream is broad and open and in its lower reaches lies in beds of sands, clay, and white quartz gravel, with some beds of lignite which are thought to correspond with the base of the Tertiary as exposed in Healy Creek.

Both the gravels of the main stream and the low bordering bench gravels carry gold which is in places sufficiently concentrated to yield good pay. The values, however, are unevenly distributed, especially on the benches, and no well-defined continuous pay streak has been found on them. In the main stream the difficulties of securing proper drainage have prevented thorough prospecting. The water supply on upper Rex Creek is too small for extensive workings, between one and two sluice heads being available during the summer.

The ground worked ranges up to 6 or 8 feet in depth, the pay all being found close to bedrock, which consists of decayed schist and into which the gold has penetrated to a depth of about a foot. The gold is bright and fairly coarse, and the gravels contain no bowlders too large to handle.

TATLANIKA BASIN.

Tatlanika Creek.—Tatlanika Creek drains an area east of the basin of the Totatlanika, the streams being 8½ miles apart where they reach the Tanana Flats. It is formed by the union of Sheep and Last Chance creeks, both of which head well back in the high mountains. These streams on emerging from the main range cross areas of much slighter relief, then enter gorges cut through quartz-feldspar schists, and below their junction enter a broad open basin in unconsolidated sands, clays, gravels, and some lignite, through which the stream has developed a gravel floor many hundreds of feet in width. The coal-bearing series at this place is thought to be much younger than that occurring on California Creek. Through this broad basin the stream continues for more than 10 miles, abruptly entering another rock canyon from which it enters the gravel plain of the Tanana. In the basin above the lower canyon the Tatlanika receives tributaries from both the east and the west, those from the east being somewhat larger and having more deeply incised valleys. Three of the eastern tributaries, Grubstake, Roosevelt, and Hearst creeks, have yielded placer gold.

Grubstake Creek.—Mining has been carried on more or less continuously on Grubstake Creek since 1905, though only a few men have been employed there at any one time. The valley of the creek lies along the line where the high gravels join the schist ridge to the south and the basin includes portions of both the schist and the high gravel areas. Workable placers have been found only for a mile or two above the mouth of the stream, which has here cut a valley 200 to 300 feet deep through a wide gravel terrace into the beds of the underlying coal series. Where the stream gravels are worked they lie on a soft bedrock of clay, sand, or coal, the pay being found in the lower foot or two of the gravels or on the bedrock. The pay streak varies from 25 to 75 feet in width, and the gold is flat, well worn, and rather fine, containing few coarse pieces. Though the gravels contain some bowlders of a large variety of rocks, derived both from the high gravels and from the schist, most of the material is small enough to be easily handled. About one sluice head only of water is available throughout the season, so that operations are restricted to open-cut workings. It is reported that in 1910 two men were mining on this creek in ground which yielded a satisfactory return.

Roosevelt Creek.—Roosevelt Creek joins the Tatlanika about 3 miles below the mouth of Grubstake Creek. It heads in a high ridge composed of unconsolidated gravels, sands, and clays and has no hard bedrock within its basin. The workable placer ground lies in the lower 2 or 3 miles of the valley, which is here comparatively shallow and open, without high bordering ridges. The placer deposits occur in stream gravels supplied by erosion of the high gravel covering of the ridge in which the stream heads, and the placer gold is doubtless the product of the reconcentration of gold from the same high gravel beds. In the absence of hard bedrock the gold is concentrated on a soft bedrock, consisting of clayey or sandy layers of the coal-bearing series into which the stream has cut its channel.

The ground worked is shallow and the values are obtained from a pay streak 20 to 60 feet wide. The gold is flat and fine, and its worn appearance indicates that it has traveled far from its original source. An insufficient water supply has retarded development on this creek, and the production for the last few years has been unimportant. Mining was in progress at one place on a small scale during the season of 1910.

Hearst Creek.—Hearst Creek enters the Tatlanika from the east, a little more than a mile below the mouth of Roosevelt Creek, and also heads in the unconsolidated deposits, with the lower part of its valley cut into the sands and gravels of the coal-bearing series. In the absence of hard bedrock the gold has been concentrated upon the more favorable of the unconsolidated beds. Since 1905 a few thousand dollars' worth of gold has been recovered from this valley, but no information could be obtained of mining there during 1910.

GOLD KING CREEK.

Gold King Creek is the first stream of importance east of the Tatlanika and flows through the foothill belt with a course somewhat east of north to the Tanana Flats, in which it joins Wood River. It heads in a high ridge of quartz-feldspar schists through which it has cut a deep notch. From the schists it passes out into the area of high gravels, and its valley 10 miles below its head is incised 1,200 to 1,500 feet below the surface of the ridges to the east and west. These ridges were originally part of a gently sloping plain built up of gravels from the mountains to the north, and in many places portions of the original surface of this plain are still preserved. The materials are for the most part well-washed gravels of moderate size, with some sandy and clayey beds, but some portions of the deposit contain bowlders as much as 2 feet or more in diameter. The bowlders and pebbles are all of rocks which can be recognized as having come from the ridges to the north. The stream was nowhere observed to have cut down into the coal-bearing series which probably underlies the gravels.

Mining has been carried on in the stream gravels of Gold King Creek since 1903. The ground worked has ranged in depth from 2 to 8 feet, the principal drawback being the presence of many large bowlders, derived both from the rocks at the head of the valley and from the high gravels. The natural tendency for a stream cutting through gravel beds is to concentrate the large bowlders as well as the heavy metallic contents in the stream channel, the finer and lighter material being carried away. Water is usually sufficient for small mining operations, three or more sluice heads being available even in periods of low water, and in wet seasons the flow of the stream is large. The gold is said to assay $17.82 an ounce and is flat, well worn, and rather fine. It is found either in the stream gravels or on a soft clayey bedrock. In 1910 mining operations were conducted on two claims, Nos. 19 and 21 below Discovery, and the yield at both places was reported to be satisfactory.

In the valley of Gold King Creek, as well as at a number of points in adjacent creeks, large areas of ground have been staked by those who intend to mine the extensive deposits of high bench gravels into which the stream valleys are cut and which cover a wide area all along the foothill belt in this region. These gravels in the valley of Gold Creek are more than 1,000 feet in thickness and no facts are known as to their depth in the valley bottom. For a number of years these high gravels have been known to be gold bearing, and from them many of the producing placers have been derived by stream concentration. Reports of men who have prospected in different parts of the high-gravel area show their gold content to range from fine colors to 3, 5, and even 15 or 20 cents to the cubic yard. The lower returns are usually from the gravels near the tops of the ridges, and the higher values have been found along the lower slopes. This fact is significant and probably indicates that the values in the richer ground have come from a concentration by erosion from the gravels above rather than that the actual gold content of the gravels increases as the deeper-lying beds are reached. Further evidence of the low average content of the high gravels can be obtained by comparing the amount of material eroded in those valleys which lie wholly within the area occupied by these gravels and the richness of the placers in these valleys. Although some of the gold derived from the high gravels might well be expected to have moved on down these streams, yet if the original gravels carried any considerable values it would be expected that the present stream gravels would be much richer than developments have so far proved them to be. Great care should therefore be exercised when prospecting the high gravels to drive tunnels far enough into the deposits to reach undisturbed beds which have certainly not been enriched by gold from above. Only by careful sampling in this way can the actual gold content of the beds be determined.

By far the largest project under way in the Bonnifield region, and one which may have a most important influence upon its future development, is that of the Berry & Hamil Co., which is making preparations to mine on a large scale the high gravels in which the basins of Gold King and Bonnifield creeks have been eroded. The company controls a large acreage of land in these two valleys. No mining has so far been done, but during the last summer 45 men were employed in building ditches and roads, erecting buildings, etc. It was expected that the ditches would be completed during the summer so that active work might be commenced early in the spring of 1911. The ditches include one 2½ miles long and one 2 miles long, to take water from the heads of Mystic and Moose creeks, respectively, and drop it into the upper end of the Gold King drainage basin; another, 6½ miles long, to take the water from upper Gold King Creek to the cut on claim No. 5 below Discovery; and a fourth, a little more than a mile long, from Gold King to the cut. The long ditch, which is to supply water under pressure for the hydraulic giants, will carry 3,000 miner's inches of water and will give a head of 700 feet at the cut. This is more pressure than will be needed, but the ditch has been so laid out that its continuation will cross the ridge into the Bonnifield basin and will furnish sufficient water for operations on both streams. The giants, with 4-inch nozzles, have been set, and the cut opened so that sluicing may be begun without delay. The timber for flumes, sluice boxes, building, etc., is sawed at the company's mill located some miles below the mine workings. Most of the upper portion of the valley is timberless. So far as could be learned on the ground it appears that the deposit to be worked has not been extensively prospected, and its gold content can be accurately known only when some considerable body of it has been sluiced. Conditions should be favorable here for the handling of ground at a very low cost per cubic yard, as a very high gravel face will be had when the cut is run back into the hill a few hundred feet. Furthermore, although some large bowlders occur in the gravels, most of the material is fine enough to be readily handled with the giants, and with the high pressure available it is largely a question of water supply. If the ground proves to be rich enough to warrant it mining will be established on a permanent basis in this region, as the gravels are practically inexhaustible and are so widely distributed that the water from a large number of streams could be used in their exploitation.

DRY CREEK (LITTLE DELTA DRAINAGE).

Dry Creek heads in the high schist mountains and flows north to the Tanana Flats, draining a basin which lies just east of that of Wood River. In the foothills the stream has a large volume of water, but much of its water is said to sink into the gravels and disappear soon after reaching the flats. Above the mouth of Newman Creek, its largest tributary from the east, the valley is cut into schists. Below Newman Creek, for a distance of 5 miles, the stream flows through a wide valley cut through high gravels into the coal-bearing formation, then enters a schist canyon through which it flows for about 5 miles, emerging into the broad, flat valley of the Tanana.

The stream gravels of Dry Creek are known to carry gold, and the valley floor has been staked for a few miles above the mouth of Newman Creek and considerable prospecting done. The gravels are from

4 to 8 feet deep and lie upon schist bedrock. Pay as high as $3.50 per square yard of bedrock has been found, but large bowlders are numerous and the ground proved too wet to work without establishing a bedrock drain, an undertaking which has so far discouraged the owners.

Caribou Creek, a tributary of Dry Creek from the west about 7 miles below the mouth of Newman Creek, flows through a valley which is in high gravels at its head but in schist in its lower portion. In 1909 two men made fair wages by working the stream gravels, but the ground appears not to have been rich enough to encourage them to return, and no work was done on this stream during 1910.

Newman Creek drains a basin which includes schists, the coal-bearing series, and high gravels. The stream gravels carry some gold, and the high gravel hills are also auriferous, reported prospects from the upper beds of the high gravels showing a yield of 3 or 4 cents a cubic yard, with values increasing somewhat in the lower beds. At the base of the high gravels, which are similar to those already described for Gold King Creek (pp. 226–228), there is a bed of clean rounded white quartz pebbles, locally known as the "white channel," on which there seems to be some concentration of gold. Newman Creek has so far not produced gold in commercial quantities, but a project is under way to exploit the high gravels on a large scale. One party has staked 125 association claims of 120 acres each in the basins of Newman Creek and West Fork of Little Delta River, water for hydraulicking to be taken from the latter stream. It was expected that the ditch would be surveyed during September, 1910, and active construction started in the spring of 1911.

Portage Creek is a small tributary of West Fork of Little Delta River and has a basin in the high gravels east of the head of Newman Creek. Placer mining of the stream gravels has been carried on continuously for the last five years by one outfit, the pay being concentrated on a clay bedrock. No hard bedrock occurs in this gulch. The total production of the creek to date is estimated at $10,000.

LODE MINING.

The wide distribution of placer gold in the Bonnifield region has attracted the attention of many prospectors to the search for placer mines, yet comparatively few men have been seriously engaged in the search for the lodes that must have furnished the gold to the gravels. Both the geologic and the physiographic evidence at hand point to the high schist mountains of the Alaska Range as having been the ultimate source of the gold, and these mountains hold forth considerable promise to the hard-rock prospector. Associated with the schists of the main range which have been correlated with the Birch Creek schist of the Fairbanks region, and also cutting the quartz-feldspar schists to the north, are many intrusive granitic rocks, and there is some reason to believe that the mineralization of the schists may be due to these intrusions. The schists in the neighborhood of such granite and diorite masses are therefore the most promising fields for the search for mineral-bearing lodes. Lode prospecting has so far been confined largely to the basin of Wood River.

CHUTE CREEK.

Chute Creek is a tributary of Wood River from the east. It is 5 or 6 miles long and flows in a deep narrow-bottomed gorge through a complex series of schists cut by intrusives. In 1908 a certain zone of the schist series was discovered by J. C. Rogers, a prospector, to be considerably mineralized with iron pyrite and to carry gold values. The lode is an altered igneous rock which weathers to conspicuous red and yellow colors and is filled with extremely small cubes of finely disseminated pyrite. The mineralization was observed to occur in a zone which has a width of over 100 feet, striking nearly north and south, and which has a high dip, so that a large body of pyritized rock is exposed. The same rock, or a very similar one, occurs in the valleys of Sheep Creek to the south and of Dry Creek to the east. In 1909 a 3-stamp mill was installed on Chute Creek and operated for about a month. In August of that year the mill was washed out by a freshet and it has since been removed to another part of the country. A 30-foot tunnel driven this year into the ore body shows no changes in the rock other than those due to protection from surface weathering.

The owners report that assays show a yield of $5 in free gold and $4 in concentrates.[1] The rock milled is also reported to have carried values of about $9 a ton. Assays of similar rocks from Chute, Sheep, and Dry creeks all showed traces of gold, though no attempt was made to sample any ore body. If further tests prove the average gold content of this mineralized zone to be anywhere nearly equal to the values reported, there is here an opportunity to develop mines in which the large supply of ore and the favorable conditions for mining should allow a liberal margin of profit over the cost of production. A rather good grade of lignite coal could be procured for power within 5 miles of the ore croppings.

KANSAS CREEK.

Kansas Creek is one of the larger tributaries of Wood River from the east. In its basin, as well as in that of Copper Creek, which enters opposite Kansas Creek from the west, bodies of a black quartzitic rock which are reported to carry gold values are associated with the schists. The only development work which has been done in these

[1] Brooks, A. H., Mineral resources of Alaska—Report on progress of investigations in 1909: Bull. U. S. Geol. Survey No. 442, 1910, p. 36.

bodies is on Kansas Creek, where, it is reported, a 90-foot tunnel has been driven into such a black quartzitic bed, which shows disseminated pyrite. No report of the assay value of this rock was obtained.

COAL DEPOSITS.

GENERAL DESCRIPTION.

The coal-bearing rocks referred to frequently in the preceding pages occupy a large area in the foothills north of the main range. They have their greatest known development and offer the best exposures on the western edge of the area under discussion and were visited as far eastward as Wood River and their approximate distribution mapped by L. M. Prindle in 1906. During the summer of 1910 further information was obtained regarding the areal extent of this important series, and numerous exposures were found which extend the limits of the formation eastward to the neighborhood of Delta River. Reports from prospectors also show that coal, probably of the same age, occurs both east of the Delta and west of the Nenana, so that further investigation may extend this field both east and west much beyond its limits as now known. It also seems highly probable that the coal series underlies parts of the areas of high gravels and of the Tanana Flats. From the facts now known no estimates can be made of the possible coal resources in the region where the formation is completely covered by later deposits, as the coal beds may there lie too far below the surface to be economically available, and the large supply of more easily accessible coal will certainly be used before an attempt is made to use that which is more deeply buried.

The coal-bearing beds, where best known, lie in low troughlike areas between the east-west ridges of schists which form the foothills. The series consists of sands, clays, gravels, and coal, the beds being in general but slightly cemented. The base of the series is composed of beds of pebbles and angular or partly rounded bits of quartz in a matrix of white sandy clay, or of kaolinic material, which where exposed is conspicuous for its whiteness. This is succeeded by alternating sands, clays, and coal, the coal beds being in general thicker toward the base of the series and becoming thinner toward its top. One section shows an aggregate of 230 feet of coal, of which over 200 feet is in beds 4 feet or more thick, and in other less complete exposures the total thickness of coal measured was in many places from 50 to 130 feet, single beds reaching thicknesses of 20, 30, or even 40 feet. In many places, too, certain of the coal beds have been burned out, leaving the adjacent beds burned to a bright tile-red. Where this has occurred, the beds just above are in places brecciated and much disturbed by caving down to fill the void left when the coal burned out. The red baked beds are much harder than the associated unconsolidated deposits and have retained the imprints of fossil leaves which show the coal series to be of Tertiary age.

The coal or more properly lignite beds of the Kenai formation vary considerably in character, being firm and compact and commonly very thick lignite beds near the base of the section but becoming thinner and more woody as the upper beds are reached. No openings were seen which would give an opportunity to collect fresh unweathered samples for analysis, but the surface croppings of the lower beds furnish a fuel which has had some small local use and which is said to burn freely and without much ash. Though probably of too low a grade to ever compete with the better coals of the coast for export, it would find a ready market for use in the interior of the Territory. It also offers exceptional opportunities for the development of power in the coal fields for electrical transmission to points in the Tanana Valley. Fairbanks is less than 60 miles from the nearest of these fields and well within the zone of economical transmission.

A heavy series of gravel beds overlies the Kenai formation at many points and was probably once continuous over much of the foothill area, but erosion has now removed the gravels in many places where their former presence is shown only by small patches or by scattered pebbles. The exact stratigraphic position of this gravel series is still in doubt and can be determined only by more detailed investigation. No determinable fossils have so far been found in it. It seems to be distinctly older than the glacial deposits and occurs at elevations above those reached by the ice at its greatest development, being folded and tilted more than the Pleistocene deposits. Near the Nenana it seems to be structurally conformable and continuous with the top of the coal-bearing beds and was thought by Prindle to be a continuation of the Kenai formation. At points farther east, however, it seems to overlie the Kenai unconformably, and the writer is disposed to think that an erosion interval elapsed after the Kenai before the high gravels were laid down. It is possible, however, that different conditions existed in different localities and that the gravels may be continuous and conformable with the coal-bearing beds in some places and unconformable in others.

LOCAL DESCRIPTIONS.

Healy Creek.—The valley of Healy Creek is occupied by the coal formation for about 10 miles above its mouth. In a general way these beds form a synclinal trough with its axis parallel to the valley. The stream follows the trough of the syncline in its upper end, but lower down it crosses some of the beds. The deposits lie in a basin in the schists, upon which they rest unconformably on both limbs of the basin, the dips of the coal beds ranging from vertical in a few places to horizontal at the bottom of the trough. Near the east end of the coal basin Healy Creek flows for more than a mile in the trough of a coal bed which forms the banks of the stream on both sides. The folded coal beds have suffered vigorous erosion both by streams and by glacial ice and in upper Healy Creek much of the series has been removed. A measured section about 6 miles above the mouth of the stream shows a thickness of about 1,500 feet of these beds, and here the upper part of the series is missing. Near the mouth of the stream a carefully measured section gave over 1,900 feet of the coal series, with about 2,000 feet of the overlying gravels. The coal series may or may not be complete at this point. At the two places where measurements could best be made the total thickness of coal found was, in the section near the mouth of the creek, 230 feet in 23 beds, of which seven beds contain 174 feet of coal. A section 6 miles east of the above showed 130 feet of coal, of which four beds contain 80 feet. As some beds of coal have been burned out in almost all sections examined, the above measurements probably fall short of the original thickness.

Lignite Creek.—The Lignite Creek coal basin is separated from that of upper Healy Creek by a high schist ridge, but the two fields are probably continuous at these lower ends. It extends eastward beyond the head of Lignite Creek and includes areas at the headwaters of Totatlanika and Tatlanika creeks. In its eastern end exposures are few and poor, as the streams have made only shallow cuts into the beds, but sufficient outcrops of coal were seen to place most of the basin among the known coal-bearing areas. By far the best exposures are to be found in the valley of Lignite Creek and its tributaries, which have cut sharp, steep-sided valleys as much as 1,000 feet into the coal-bearing beds, without, however, anywhere exposing the underlying schist in the center of the valley, so that the lower part of the series is not shown. The beds, like those in Healy Creek valley, lie in a basin bordered by schist ridges and old intrusive rocks, the beds dipping away from either border toward the center of the valley. Although at some points along the borders the dips are high, being as much as 45° on the south side of Jumbo Dome, in general the coals of Lignite Creek lie much flatter than those of Healy Creek, and through most of the valley they appear to the eye to be horizontal. The beds consist of cross-bedded sands, soft blue shales, some fine, loosely cemented conglomerates and gravel beds, and coal. In the deeper exposures the coal is hard and dense and the beds are heavy, but toward the upper beds the coals become woody and fibrous, with much shaly material, and the beds become successively thinner. As the coal series of lower Healy and Lignite creeks is overlain by a thick deposit of gravels, its actual areal distribution is much greater than is shown by a map of its surface occurrence.

A section of the coal series measured by L. M. Prindle, about 6 miles above the mouth of Lignite Creek, gives 129 feet of coal in a total thickness of 726 feet of beds. Of this more than 100 feet occurs in beds 8 feet or more thick. Another, about 2 miles farther upstream, shows 48 feet of coal in a section 170 feet high. These two exposures show only part of the whole series, and the total thickness of coal in the complete section is doubtless much greater than that of either.

California Creek.—California Creek heads on the south side of Jumbo Dome, in the Lignite Creek coal field. North of this dome it flows through another area underlain by the coal-bearing series, which crops at the surface over about 15 square miles. The beds here have the same structural relations as elsewhere, lying in a basin bordered by schist ridges and dipping toward the center of the basin. The dips, however, are gentle, and through much of the field the beds are nearly horizontal or lie in gentle wavelike swells. The streams have nowhere made deep cuts through the coal series, and the thickness seen is probably much less than the actual thickness, as there may be many coal beds below, no surface outcrops of which were seen. The extent of the field is also greater than the surface distribution, for along its western edge the coal beds are overlain by a heavy deposit of gravels. They are composed of sands, shales, and white kaolinic materials containing quartz fragments and pebbles, and beds of lignitic coal. Along the main stream for several miles a heavy coal bed 12 feet thick shows in the stream bluffs, in places dipping below the stream bars but in general lying nearly flat. Other croppings of the same or a similar bed show in tributary valleys to the east, so that it is probable that the field contains at least 12 feet, and probably more, of coal throughout its area.

In the basin at the lower end of California and Rex creeks the beds of the coal series cover an area of about 20 square miles. In character they are similar to those on upper California Creek and are conspicuous for the prominent white bluffs exposed along Rex Creek and for a bright-red color in many places where the coal has burned out and baked the adjacent beds. Some woody coal was seen on a small tributary south of Rex Creek, but no workable coal beds are known in this basin.

Tatlanika basin.—On the east side of the Tatlanika Valley, in lower Grubstake Creek and between Roosevelt and Hearst creeks, the clays, sands, and coal beds of the coal series outcrop, and it is reported that similar beds occur as far north as the head of the lower canyon of the Tatlanika. Little is known of the amount of coal present, although a bed 12 or 15 feet thick is said to outcrop at the surface, dipping at a low angle to the east. No development of the coal has been attempted here, but its occurrence is of interest, as it affords strong additional evidence that the area of high gravels is underlain by coal between Tatlanika and Wood rivers.

Wood River basin.—In the valley of Mystic Creek and westward to that of Moose Creek the coal-bearing beds have an area of about 7 square miles. One section shows 30 feet of coal in two beds, and at another point the upper 10 feet of a coal bed outcrops. The coal has here been used for cooking and heating in a camp of 25 men, with very satisfactory results. The total thickness of the series and of the contained coal beds is nowhere exposed.

At the head of Coal Creek, which joins Wood River 4 miles below the mouth of Mystic Creek, the coal series is exposed, dipping steeply from the schist ridge to pass beneath the high gravels north of Coal Creek. No opportunity was had to study this section closely, but some 16 coal beds were seen, the aggregate thickness of which will reach more than 100 feet. In the uplift and crumpling of the beds the coals may have been given a greater thickness here than they possess farther to the north, but unquestionably there is a valuable coal field beneath the high gravels, concerning the extent of which we know little.

Dry Creek basin.—In the valley of Dry Creek, at the mouth of Newman Creek, 140 feet of the coal series is exposed beneath the high gravels. Coal beds at this place have been on fire for at least five years and are still burning. Prospect holes and coal croppings, while giving little information in regard to the thickness of the coal beds, show that the series with workable coal beds lies beneath the high gravels on Dry Creek.

Isolated coal croppings in the basins of Little Delta River and Delta Creek also indicate that the coal is widely distributed and may underlie large areas of the high gravels as far east as Delta River.

GOLD PLACER MINING DEVELOPMENTS IN THE INNOKO-IDITAROD REGION.

By A. G. Maddren.

INTRODUCTION.

Although several of the pioneer American prospectors of interior Alaska are known to have entered and passed through parts of the Kuskokwim Valley as early as 1889, and others are said to have visited the Innoko Valley as early as 1898, placer gold in paying quantities was not discovered in this part of Alaska until 1906. In the summer of that year gold was found on Ganes Creek, one of the principal headwaters of Innoko River, and since then a placer camp, with an average population of 150 working miners, has been maintained in the upper part of the Innoko Valley. (See map, Pl. XI.) A settlement named Ophir, situated on the main river at the mouth of Ophir Creek, has been the center of this community since the spring of 1908. The Innoko district, in spite of many discouraging circumstances, due chiefly to its isolation and difficulty of access, has established itself as a worthy producer, and from 1908 to 1910, inclusive, its placer-gold output has totaled about $750,000. This has served to stimulate interest in the gold-bearing possibilities of the streams which drain either side of the Kuskokwim Mountains and flow into Yukon and Kuskokwim rivers. Up to the present time, however, the Innoko district has suffered from a chronic scarcity of both provisions and mining equipment, and in consequence of the high costs that have prevailed very few persons have felt justified in expending much time or money in prospecting the outlying parts of the district. The result is that after three years very little is yet known about the gold-bearing possibilities of a wide extent of country that is drained by the northeastern headwaters of the Innoko and the tributaries of Nowitna and Kuskokwim rivers adjacent thereto. Prospects of placer gold are reported to occur upon the headwaters of the Nowitna, a tributary to the Yukon that lies northeastward from the northeastern headwaters of the Innoko, and upon the Tuentna or Nixon Fork, the large northeastern branch of the Takotna, situated east of the upper Innoko, but no productive mining has been developed within these basins to date—in fact, no genuine prospecting has been done within them, although considerable wholesale locating of ground, especially in the Tuentna Valley, has been done by a few speculative individuals using powers of attorney in the unrestricted manner now practiced in Alaska.

Prospects of gold also occur on small streams that drain the northeast end of the Kaiyuh Mountains, which bound the west side of the Nowitna Valley. Several thousand dollars' worth of gold has been mined from a short gulch stream named Reeley Creek, tributary to the Yukon, opposite the mouth of Melozitna River.

Southwestward from the Innoko district more has been accomplished than toward the north and east. Some prospecting has been carried on at intervals since 1907 on eastern tributaries of Tolstoi Creek, a large branch of Dishna River, and it is said that fine colors of gold are so widely distributed within the deposits of the valleys of Madison and Mastodon creeks that prospects may be obtained at a number of places. So far, however, no concentrations of gold of sufficient worth to pay to mine have been found on any of the tributaries of Tolstoi Creek.

Since 1908 a little prospecting and a great deal of locating have been done along both the northwest and southeast flanks of the Kuskokwim Mountains where they separate the headwaters of the Dishna and Iditarod, tributaries of the Innoko, from those of Takotna, Black, and George rivers, tributaries of the Kuskokwim. (See map, Pl. XI.) During the winter of 1909–10 colors of gold were found on Deadwood Creek, a headwater of the southwest fork of the Dishna, and some open-cut pick and shovel work was done there in the spring of 1910 by several men but was soon discontinued because it did not prove profitable under present conditions. Extensive locations for placer mining have been made in this vicinity on Deadwood, St. Patrick, and other creeks tributary to the southwest fork of the Dishna and also across the divide at their heads to the south on July, Willow, and Moore creeks, which are headwaters of Takotna River, a tributary of the Kuskokwim. Very little work has been done on these locations—in fact, on most of them none at all. Moore Creek is the only one upon which gold in paying quantities has been found to date, but no production to speak of had been made there up to 1910. This general locality, however, appears to be worthy of careful prospecting.

In the later part of the summer of 1908 two prospectors, W. A. Dikeman and John Beaton, who had been to the Innoko district earlier in that year but were not encouraged by the outlook there, descended the Innoko in a small steamboat. Upon reaching the large southwestern branch of the Innoko, now named the Iditarod, these two men decided to explore that stream and prospect on its headwaters. They ascended the Iditarod as far as the low stage of water of that season would permit their boat to go and there prepared for winter by building a log house which has since been called "Discoverers' Cabin." This house is situated on the main river about 8 or 9 miles below the present town of Iditarod, or some 25 miles below the mouth of Otter Creek. During the early winter they sledded a prospecting outfit southward from their winter quarters across several low ranges of hills to Otter Creek and decided to look for gold in the valley of that stream at a point about 12 miles above its mouth. Their choice of a location to prospect, decided upon at haphazard, as it was in midwinter, proved most fortunate, for they were rewarded by finding gold at a depth of only about 12 feet in the first holes they dug to bedrock, the discovery being made on Christmas day, 1908. The discoverers then located a moderate number of claims for about a mile along Otter Creek for themselves and a few friends.

Owing to the distance of Otter Creek from settlements or routes of travel and to the fact that the discoverers were practically alone, information about the newly found prospects of gold did not spread rapidly. It was not until the summer of 1909 that other prospectors gathered there from the Innoko and Yukon districts. The result of their arrival was the locating of claims that covered practically all the valley lands of Otter Creek, its tributaries, and the adjacent streams. Almost no mining was done during the summer of 1909 because of the lack of equipment and supplies. During the later part of this summer most of the several hundred people on the Iditarod were chiefly concerned with getting enough supplies at hand to enable them to remain through the coming winter. Considerable amounts of supplies that were shipped to the new district did not arrive because Iditarod River was at a low stage during the open season of 1909 and navigation was closed by ice earlier than usual that autumn.

In spite of these handicaps some systematic prospecting of the claims on Otter Creek was undertaken during the winter of 1909–10 and some gold was mined from small underground drifts. The reports about this work were either sent out in such optimistic form or became so magnified in transmission that a great deal of interest was aroused about the new district, with the result that when navigation opened on the Yukon in May, 1910, a couple of thousand people and a considerable amount of supplies and machinery were bound for the Iditarod. Until the middle of July the traffic to the new camp taxed the capacity of the available steamboat transportation on the Yukon and for a time the movement threatened to reach the proportions of a so-called stampede. The total gold production of the Innoko and Iditarod districts in 1910 is estimated to have a value of $825,000.

GEOGRAPHY.

When gold was discovered on Otter Creek in 1908 all of the Innoko basin constituted a subdivision known as the Innoko precinct and was included in the second judicial division of Alaska, whose court offices are at Nome. This precinct, with its recording office at Ophir, was bounded and described as follows:

Beginning at a point on the eastern bank of the Yukon River, about 50 miles above the village of Anvik and opposite the divide between the Innoko and Yukon rivers; thence following the divide northeasterly to the divide between the Innoko and the Nowi rivers; thence in an easterly direction or southeasterly direction following the divide between the Innoko and the Nowi rivers to a point on the divide between the Innoko and Kuskokwim rivers; thence in a southwesterly direction following the divide between the Innoko and Kuskokwim rivers to the western bank of the Yukon River at a point south of Holy Cross, this last-mentioned line being identical with a part of the northern boundary line of the Kuskokwim precinct; thence northerly along the western bank of the Yukon to the place of beginning.

An act of Congress taking effect July 1, 1909, resubdivided Alaska into four judicial divisions instead of three and placed the original Innoko precinct in the fourth division under the court at Fairbanks. A new adjustment of several precincts was made necessary by this redivision and to facilitate recording matters the Innoko precinct as formerly defined was divided into two precincts, the recording office at Ophir being retained to accommodate the miners in the eastern headwater portion of the Innoko Valley, and a new precinct named Otter being formed to include the Iditarod placer-gold district or western part of the Innoko basin. The recording office for the Otter precinct is at the town of Iditarod.

The Iditarod gold-placer district is situated along the upper valley of Iditarod River, about 65 miles east of the settlement of Holy Cross or Koserefski, on the lower Yukon. (See map, Pl. XI.) Iditarod River is the largest branch of Innoko River, which is the largest eastern tributary of the lower Yukon. The Innoko joins the Yukon about 300 miles from Bering Sea. It flows into the Yukon through two or more divergent and crooked channels in which the currents are so sluggish that they are generally called sloughs. The channel most frequently used by the steamboats that ply the Innoko and Iditarod enters the Yukon a few miles below and opposite Holy Cross. This channel may be considered the mouth of the Innoko. The lower 150 miles of the Innoko is commonly but incorrectly called Shageluk Slough, owing to the fact that a side channel of the Yukon flows into the Innoko at that distance above its mouth. This channel, which is about 35 miles long and navigable for steamboats, leaves the main Yukon about 80 or 90 miles above Holy Cross. It delivers a considerable amount of Yukon water to the Innoko and is of considerable consequence in increasing the volume of the lower 150 miles of that river, but the Innoko proper furnishes by far the largest amount, and although many persons consider the mouth of Innoko River to be at the confluence of Shageluk Slough with the Innoko and name the lower 150 miles of the Innoko channel Shageluk Slough also, this designation should be restricted to the side channel that carries Yukon water exclusively.

The main Innoko River is about 500 miles long and with its tributaries drains the largest part of an extensive area that lies between the central lower courses of Yukon and Kuskokwim rivers. Its principal or northeastern headwaters, upon which the Innoko placers are situated, lie between the Kaiyuh Mountains on the northwest and the Kuskokwim Mountains on the southeast, these ranges separating its upper valley from the drainage of Yukon and Kuskokwim rivers, respectively.

The southern portion of the Innoko basin is drained by Iditarod River and its tributaries. The chief or eastern headwaters of this stream rise along the divide of the Kuskokwim Mountains about 75 miles east of Holy Cross and drain an extensive area that lies along the northwestern slopes of these mountains. Iditarod River flows into Innoko River about 45 miles above Shageluk Slough, or 200 miles from Holy Cross by the regular steamboat route. In direct distance its source is not more than 100 miles south of its mouth, but the total length of the actual course of the Iditarod is probably 300 miles, as it has an extremely meandering channel, especially throughout its lower portion, for both the Innoko and Iditarod meander widely for many miles through sluggish channels across swampy plains that occupy the lower half of the Innoko Valley. During the spring freshets the whole lower valleys of these rivers are inundated, and after the floods have subsided large areas of swamps, shallow ponds, and lakes remain over its surface.

Iditarod River drains a considerable area on the southeastern side of lower Yukon Valley along its southeastern boundary, the Kuskokwim Mountains. The upper 100 miles of its course is along the northwestern foothills of these mountains and the river receives its chief headwater tributaries from them. Broadly considered the Iditarod district comprises an area of about 500 square miles that is drained by several of the larger eastern tributaries of this river. In upstream order these tributaries are named Caribou, Otter, and Bonanza creeks. Extensive locations for placer mining have been made throughout the valleys of these streams, but the area within which actual discoveries of placer gold have been made and mining operations undertaken is much smaller and may be included within a tract 10 miles square. Practically all the productive placer ground now known lies within the valley of Otter Creek and about the sources of several small streams just south of Flat Creek, which is the most important gold-bearing tributary of Otter Creek.

TRANSPORTATION, SETTLEMENTS, AND POPULATION.

The only practical way of transporting supplies to this district is by means of shallow-draft stern-wheel river steamboats plying Yukon, Innoko, and Iditarod rivers. During 1910 most of the freight was brought up the Yukon to Holy Cross on large steamboats and there transferred to smaller ones which ascended the Innoko and Iditarod to the supply points that have been established at several places along its course. Considerable freight, consisting largely of mining machinery, was also brought down the Yukon from Fairbanks and taken to the new district by way of Shageluk Slough and Innoko and Iditarod rivers.

During the stages of high water that prevail in these rivers in June and sometimes at other periods during the summer months steamboats of moderate size are able to ascend the Iditarod as far as the mouth of Otter Creek, a distance of about 216 miles above its mouth. During the average summer stages of water, however, the moderate-sized steamboats can not ascend the Iditarod so far, and the upper settlements can be reached only by much smaller steamboats and launches. This variable condition of the navigability of the river has determined the location of the supply settlements on the Iditarod.

At present there are three such settlements of importance on Iditarod River. These, in down-river order, are named Otter, at the mouth of the stream of that name, which is about 216 miles above the mouth of the river; Iditarod, situated about 16 miles by the course of the river below Otter; and Dikeman, which in air-line distance is only 29 miles but by the river 70 miles below Iditarod. Dikeman is about 130 miles up the Iditarod from its mouth, or 330 miles from Holy Cross by the steamboat route, and the town of Iditarod is about 400 miles from Holy Cross.

Dikeman is situated on the east bank of Iditarod River where it leaves the low foothills that border its upper course. The river from Dikeman to the Innoko flows sluggishly 130 miles by a very tortuous channel across the swampy plains of its lower valley. Its channel is deep enough at all stages of water for moderate-sized Yukon steamboats to ascend to Dikeman, and this point is considered the head of low-water navigation. Dikeman has been established as a storage and transfer point for freight and passengers to the placer district, and several of the larger commercial companies have built substantial warehouses and stores here for that purpose. Its population in 1910 numbered about 100 persons.

The town of Iditarod, with a population of 600 or 700 persons, has been, since its establishment in June, 1910, the commercial center of the district. It is situated on the east side of the river, 70 miles above Dikeman by the summer water route, or 31 miles by a winter sled trail recently laid out by the Alaska Road Commission. The town site is on a rather unfavorable frozen boggy bank, whose only local advantage for the purpose of settlement seems to be that it stands high enough to be above the waters of spring freshets. A number of substantial warehouses and business buildings have been erected there, and all the activities of a boom town were much in evidence during the summer of 1910.

This town is 8 to 12 miles from the mines by an overland route that is too boggy in its present condition to be of much service for hauling supplies to the mining camps with horses and wagons. Although this method of transportation was carried on during the summer of 1910 it was accomplished with great difficulty and expense, and unless a good road is built this overland route can not compete with the water route by way of the river and Otter Creek.

The settlement of Otter, at the mouth of Otter Creek, is an important point for the distribution of supplies to the mines, as steamboats can reach this place at times of high water and from it freight can be transported up Otter Creek to the diggings by means of scows towed by horses. The distances from the mouth of Otter Creek to the mining settlements on that stream are from 16 to 20 miles by the water route or from 8 to 10 miles by land.

The most important mining settlement is named Flat. It is located on the east bank of Otter Creek about 16 miles above its confluence with the Iditarod just below the mouth of Flat Creek, which is the most important tributary of Otter Creek bearing placer gold. About 2 miles above Flat, on the west side of Otter Creek, is a place named Bowlder, and from 1 to 2 miles farther up Otter Creek, on the same side of the main stream, is a straggling settlement called Discovery because it is located at the mining claim so designated.

In 1910 the population of Otter numbered about 50, and Flat and Flat Creek probably had a population of 400. Bowlder, Discovery, and the near-by claims along Otter Creek had about 300 residents. During 1910 there was also a floating population of about 1,000 men in the district, who were temporarily camped at different places along the river and creeks. In August and September about 500 of these men were busy locating placer claims on tributaries of the Kuskokwim opposite those of the Iditarod to the south. It is estimated that on an average 2,500 people were in the Iditarod region during the summer of 1910.

Supplies are transported to the Innoko district by taking them up Innoko River on medium-sized Yukon steamboats as far as Dishkakat, which, like Dikeman, on the Iditarod, is considered the head of ordinary low-water navigation for such craft. At times of high water smaller steamboats may ascend the Innoko about 100 miles above Dishkakat to the vicinity of the North Fork, some 90 miles below

Ophir. From the North Fork the freight is carried to Ophir in lots of 4 to 6 tons on light-draft scows towed by horses.

A considerable amount of supplies for the Innoko placer district is now being brought up Kuskokwim and Takotna rivers to a settlement called Takotna Station, which is about 20 miles from Ophir by a winter sled trail that crosses a low divide between the Innoko and Takotna drainage. The Kuskokwim route appears to be the best way to supply the Innoko placer district.

GEOLOGIC SKETCH.

The Kuskokwim Mountains form a divide from 2,000 to 4,000 feet above sea level between the drainage of Innoko and Iditarod rivers and that of the central part of the Kuskokwim Valley. The hard-rock formations of the region are fairly well exposed along the crest of this range and the secondary ridges which separate the streams that flow therefrom. These mountains appear to be mostly made up of a widespread series of sedimentary formations largely of Mesozoic age, with which are intimately associated considerable amounts of volcanic rocks of various kinds, some of which, at least, are older than a large part of the sedimentary formations, because fragmental detrital materials derived from the volcanic rocks are commonly interbedded with the sediments as tuffs.

The sedimentary rocks of the Kuskokwim Mountains are a series of alternating beds of sandstones, carbonaceous and calcareous shales, shaly and siliceous limestones, granitic arkoses, volcanic tuffs, and conglomerates. The sandstones are generally rather thinly bedded and flaggy. The shales range from soft to fairly hard rocks and in the Innoko district appear to be partly altered to slates. Near their contacts with granitic intrusives they have been locally hardened into blocky quartzites and argillites.

The general structural trend of the sedimentary series is northeast and southwest, with southeasterly and northwesterly dips at angles varying from 20° to 80°.

The volcanic rocks of these mountains are more or less altered rocks of basaltic types. They all have a general greenish color such as naturally belongs to ancient and somewhat altered lavas that are considerably decomposed. Closely associated with these volcanic rocks in many places occur large amounts of more or less consolidated fragmental igneous material which appears to be directly derived from the volcanic rocks and so may be classed as tuff. These beds of tuffs in places appear to change laterally into shales and sandstones of undoubted sedimentary origin, or to be at least interbedded with such rocks. The definite relations of the sedimentary formations to one another and to the volcanic rocks have not been determined, and so far as the evidence goes they may be provisionally considered as essentially contemporaneous in origin, their differences being accounted for by variations in local conditions. It may be noted, however, that the volcanic and intrusive igneous formations appear to be most extensively developed along the main divide of the Kuskokwim Mountains and that the sedimentary formations of these mountains become more free from mixture with either volcanic or intrusive rocks along both their outlying northwestern and southeastern flanks as they recede from the backbone of the range. These probable relations seem to indicate that the volcanic rocks and closely associated tuffs and sediments which lie along the center of the Kuskokwim Mountains may be older than the outlying sedimentary formations that make up the mountain flanks, and the presence of arkose sandstones, apparently derived from granitic rocks, in these flanking formations seems to indicate that the granitic masses distributed along the mountains, which may be the source of the arkose sandstones, are older than at least a part of the outlying formations. The few fragmentary fossil remains of land plants and marine-shell forms that have so far been found in these sediments point to an undoubted Mesozoic age for the series and a probable Cretaceous age for its younger members, of which the arkose sandstones appear to form a part. This meager evidence indicates that a large part of the granitic intrusive rocks are of early or pre-Cretaceous age; at any rate the older sedimentary and closely associated volcanic formations appear to have been the country rock which the intrusives penetrated.

Most of the highest areas throughout this general region are made up largely of mountainous masses of these intrusive granitic rocks. Dikelike bodies of these siliceous intrusives trend in different directions, but mostly northeastward and southwestward, across the intervening areas of sedimentary rocks in a manner that vaguely suggests that there may be a more or less connected network of intrusive dikelike bodies extending between the large intrusive centers. The dikes are ordinarily of siliceous varieties, such as biotite granites and hornblende diorites, sometimes porphyritic, although some are more basic, such as diabase porphyry and basalt. It is possible that these more basic dikes may belong to an earlier period of intrusion and be more closely connected with the volcanic flow rocks.

The sedimentary rocks are generally more or less metamorphosed near the intrusives, the degree of alteration becoming progressively less with distance from the contacts. The contact metamorphism that has occurred along these intrusives appears to have caused the conditions that have brought about, in places at least, the mineralization along the contact zones from which the placer gold has been derived.

The rocks of the Kuskokwim Mountains do not, in general, contain well-marked veins, but in the vicinity of some of the siliceous dikes the country rocks are altered, chiefly by silicification, at some places for only a few feet from the contact but at others for considerable distances, and there occur narrow vein deposits near the contacts of dikes with stratified rocks, and locally small gash veins within the dikes themselves. The material of these veins is generally quartz but in places calcite. The metallic minerals associated with these veinlets and zones of alteration are sulphides, of which iron pyrite, chalcopyrite, galena, and cinnabar are the most common kinds. Some of these minerals are presumed to be gold bearing because the placer gold is evidently derived from the decomposition and erosion of these mineralized contact zones.

OCCURRENCE AND DISTRIBUTION OF THE PLACER GOLD.

ORIGIN OF THE PLACERS.

The placer-gold deposits of the Iditarod district appear to be of distinctly local origin. As now developed, the commercially important stream concentrations of gold are small in extent and their distribution is evidently very closely dependent upon the apparent bedrock origin of the gold. The origin of the placer gold appears to be closely connected with the mineralization that has taken place locally along the contacts of siliceous intrusive rocks with the more basic igneous rocks and the sedimentary formations. For example, in the valley of Otter Creek the placer gold is found in very close association with bodies of granitic intrusive rock. Here two bodies of granite seem to be present, one lying across the valley of Otter Creek just below Granite Gulch and the other on the head of Flat Creek, a tributary on the south side of Otter Creek. These granitic masses have a width of at least half a mile and a length of 1 to 3 miles. Their longest dimensions have a northeasterly and southwesterly direction in conformity with the general structural trend of the sedimentary formations; they are in line with each other along this trend and may be connected, although this is not known to be the case.

In the Innoko district the direct local derivation of the placer gold from zones of contact mineralization is not so evident as it is in the Iditarod. There are no large intrusive bodies very near the Innoko placers, and the gold seems to be distributed farther from an apparent bedrock source. There are, however, some siliceous dikes cutting the country rocks within the valleys of the placer streams. Some of these dikes are known to be mineralized with pyrite, and it may be presumed there are more of them so mineralized. Vein quartz occurs along the walls of some of the dikes, and some of this quartz is known to contain gold. Thus it appears that the placer gold is relatively local in origin and distribution.

INNOKO GOLD-PLACER DISTRICT.

An account of the Innoko district has already been published[1] in which a general description of this region has been given and its mining development up to 1908 outlined. Therefore only a brief review and summary of the progress of mining development up to 1910 is given here.

Practically all the mining in this district has been performed within the valleys of Ophir, Spruce, Little, Ganes, and Yankee creeks. The placer gold occurs in creek, bench, and gulch deposits. Various methods of mining have been practiced according to the position and character of the deposits; sinking and drifting, groundsluicing and open cut, scraping and hoisting by steam power, shoveling and hoisting by hand, and canvas-hose hydraulicking have all been used in different combinations upon the different creeks.

GANES CREEK.

Placer gold was first mined in the Innoko district on Ganes Creek in 1907, near the place where it was discovered the previous summer. It soon became apparent to those interested in claims on this stream that the gold-bearing deposits which could be mined most profitably were not those in the present stream bed, but older gravels which rest on bedrock benches that now stand from 30 to 60 feet above the level of Ganes Creek. These benches, which are remnants of an older valley floor, are situated for the most part on the east side of the creek about 7 miles above its mouth. They are from 100 to 500 or 600 feet wide and extend along the valley for several miles, with interruptions at intervals caused by gulches that have been cut down through them by nine short tributary streams. These bench gravels have been mined each summer since 1907 at the most favorable places by half a dozen or more parties, each composed of about three to six men. The mining operations have not been conducted upon an extensive scale because enough water can not be obtained from the short gulch streams that rise along the eastern side of the valley behind and above the benches for effective hydraulicking with a large plant, and because the capital with which to purchase and install the equipment of such a plant has been beyond the moderate resources of the men who are interested in the ground. The result is that all the mining has been conducted upon selected areas of small extent in as simple and inexpensive a manner as possible. A cover of muck and silt is sluiced off with streams of water led upon

[1] Bull. U. S. Geol. Survey No. 410, 1910.

the benches from small ditches that have been dug up the short gulch tributaries. The supply of water obtainable from these gulches varies much from year to year and even from week to week during the same summer; consequently the amount of mining that may be accomplished during a given season is always uncertain. On some of the bench claims enough water for the mines can be obtained only during the spring thaw and after uncertain rains. During dry summers all mining operations on the Ganes benches are greatly handicapped by scarcity of water.

After the overburden, which varies from 2 to 12 feet in thickness, has been removed the pay gravels, which are from 1 to 6 feet thick, are shoveled into lines of sluice boxes arranged to carry the tailings over the edge of the bench or dump them into gulches cut below the level of the bench—whichever is the more convenient. From 6 inches to 3 feet of splintered and flaky slatelike bedrock which contains gold is also shoveled into the sluice boxes. Considerable areas of these bench deposits that may be worked by these methods still remain, but a large part of the most favorable ground has been mined.

Several drift-mining operations of slight extent have been conducted along the base of the rock bluffs upon which the gold-bearing gravels rest, and from this source some gold has been obtained. There seems to be no doubt that the gold found in the lower-level gravels along the base of the bluffs that form the benches and in the present bed of Ganes Valley has been derived from the deposits on top of the benches.

The total gold production of the Ganes Creek placers up to the present time is estimated to be about $150,000.

LITTLE CREEK.

Little Creek lies northwest of and parallel to the lower part of Ganes Creek, which it joins about half a mile above the Innoko. It is approximately 7 miles long and is separated from Ganes Creek by a ridge about 2 miles wide and 600 feet high.

Gold was discovered on this stream during the summer of 1907 and mining has been conducted since 1908 on claims that occupy the middle 3 miles of its valley bottom. The unconsolidated deposits vary from 10 to 25 feet in depth. In some places they are frozen and in others thawed. They consist largely of mucks and silts, with a small quantity of gravel. In some localities gravel beds 2 to 4 feet thick rest on the bedrock beneath the silts, but in many places the silts lie directly on the bedrock and gravels are practically absent. The bedrock of Little Creek is a hardened shale or argillite that varies in texture from gritty to fine grained. In places it has slaty cleavage, but most of it is massive. Its upper 10 feet is generally very much shattered. It breaks into blocky slabs and shingle fragments and also into roughly columnar 4-sided to 7-sided forms from 2 to 4 inches in diameter and from 10 to 18 inches in length. Many of these columnar pieces stand on end in the weathered bedrock, and where gold is present the best concentrations are generally found in this kind of bedrock, which acts as natural riffle blocks. From 2 to 10 feet of the upper part of the bedrock is generally thoroughly shattered in this blocky or slabby manner and the fragments are commonly separated, the spaces between them varying from one-tenth to 1 inch or more in width. These spaces are filled to a depth of 2 to 6 feet with sediment or silt, which appears to have filtered down from above. Most of the placer gold, which consists of flaky, fresh rough pieces of small size, occurs in these sediment-filled spaces in the bedrock, where it appears to have become concentrated along with the sediments that fill the interspaces. From 2 to 6 feet of the shattered bedrock is dug up in mining, and most of the gold output is obtained therefrom.

The Little Creek placers have been mined both by surface open-cut groundsluicing and underground sinking and drifting methods, the practice adopted depending upon the position, depth, and condition of the deposits. Along the valley bottom, where the deposits are deepest and contain more or less perpetual frost, considerable sinking and drifting work has been done; but this has proved profitable only where the gold happens to be concentrated in quantities above the average. Such concentrations appear to be distributed in disconnected strips and spots along the bedrock floor of the valley, but they are of uncertain extent and difficult to trace. As soon as drifts are extended beyond the limits of the richer concentrations or into thawed deposits, the underground work generally becomes unprofitable. Though it may be continued for some distance in the hope of finding other rich places, such work is more of the uncertain nature of prospecting than the mining of ground known to contain fairly uniform paying values, such as are essential to success, especially in a district like the Innoko, where all mining operations are expensive.

Underground mining would probably not be undertaken at all in the Innoko district if it were not for the lack of water in sufficient quantity for hydraulic mining and of sufficient grade to the valleys to afford dumping space for tailings. None of the workings on Little Creek is more than 30 feet deep, and if enough water could be readily obtained in this valley no doubt all its gold-bearing deposits might be cheaply mined by hydraulic methods if the tailings were elevated. But this stream is so small that the average supply of water is barely sufficient for ordinary sluicing operations, especially during summers of little rainfall. By taking advantage of the more abundant flow of water during the spring thaw and at uncertain times of heavy rainfall, surface open-cut mining has been carried on to a moderate extent at several places, both in the present creek channel and upon either side of the stream. The deposits along either side of the present stream are termed "benches" by the miners; but they are not distinct terraces, such as occur along Ganes Creek, for on Little Creek there is no abrupt break in the vertical position of the gold-bearing deposits as there is on Ganes Creek. They rest on a fairly even bedrock surface that slopes up sufficiently from the lowest part of the valley to afford dumping space for the waste material it is necessary to remove in order to lay bare the gold-bearing bedrock that occurs on either side of the stream at some places. Practically all of the waste overburden consists of silts, clays, and vegetable muck, which varies from 3 to 10 feet in thickness. There is little or no gravel present and cobbles or bowlders are not plentiful.

The waste overburden is removed in the usual manner by ground-sluicing or washing it away with streams of water led upon it from small ditches that have been dug along the valley slopes above. After the bedrock in these open cuts has been laid bare, from 2 to 4 feet of the upper shattered part is loosened with picks and washed through lines of sluice boxes to recover the gold that is lodged in the sediment that fills its crevices.

An average of six to eight outfits have mined along Little Creek since 1908. The open-cut work can be done only during the season of flowing water and then only at the times of maximum flow, which are generally in the early part of the summer. The drift mining may be carried on more or less throughout the year.

Some of the open-cut mining has produced as much as $1 to the square foot of bedrock surface, but most of it yields less than this. In the underground drifts, as in the open cuts, about 4 feet of shattered bedrock is dug up and washed for gold, and good ground will yield $1.50 to the cubic yard, but the additional cost of steam thawing, of the labor to hoist the loaded buckets from the shaft by hand windlasses, and of the unproductive work performed in extending the drifts through ground that contains little or no gold reduces the profits of work of this kind. The total production of gold from Little Creek since 1908 probably amounts to about $150,000.

SPRUCE CREEK.

Spruce Creek is northwest of and parallel to Little Creek, being separated from it by a ridge about 2 miles wide and some 800 or 900 feet high. Its valley is about 6 miles long and is similar to that of Little Creek. The country rock within it is likewise the same hard blocky shale or argillite. The creek appears to carry a little more water than Little Creek but still not enough to permit very satisfactory hydraulic operations.

The alluvial lands along this valley have been located for placer mining since 1908, and although some prospecting has been done at several places along the stream from time to time nothing was discovered that led to productive mining within its basin until the autumn of 1909, when good prospects were found on a low bench situated about 3 miles up the valley on its eastern side, about 200 yards from the present course of the stream. At this locality the creek now flows along the base of a steep bedrock slope that forms the western side of the valley, and the gold-bearing area extends eastward from it, the bedrock floor of the valley rising some 30 or 40 feet in this direction within a distance of about 500 feet. This sloping valley floor is covered by 5 to 15 feet of clay, silt, and muck, the greater part of which is frozen. The eastern rise of both the bedrock across the valley and the surface of its overburden make it practicable to groundsluice the waste mantle aside into the creek in the same manner as on Little Creek. As the supply of water obtainable from Spruce Creek is somewhat more abundant than that of Little Creek, the groundsluicing open-cut work may be carried on more continuously throughout the summer. The claims that are being mined receive water from above, brought by a ditch about 9,000 feet long that has been dug along the eastern side of the valley, so as to deliver water about 50 feet above the creek at its lower end, where it is led upon the sloping bench through canvas hose and the gold-bearing bedrock is cleared of its frozen mantle of clay and muck. The shattered bedrock, in which the gold occurs in the same manner as on Little Creek, is then loosened with picks and shoveled into lines of sluice boxes for washing.

About $20,000 worth of gold was mined from these so-called bench claims during the summer of 1910 by the open-cut groundsluicing method described above.

No productive drift mining has yet been done in this valley.

OPHIR CREEK.

Ophir Creek lies about 1½ miles northwest of and parallel to Spruce Creek. It is about the same length (6 or 7 miles) and size as Spruce Creek, and the ridge dividing them is about the same height as that between Spruce and Little creeks. In brief, all three of these valleys have very similar features of length, width, depth, direction, bedrock, and other general characteristics.

Ophir Creek differs from Spruce and Little creeks principally in that its placer gold is more abundantly and uniformly distributed along the bottom of its bedrock channel and that the valley is more evenly filled across and along its bottom with silts, clays, and muck, which for the most part are frozen and of uniform thickness. The valley filling averages 25 to 30 feet in depth. At some localities it is a few feet less than 25 feet and only in a few places more than 30 feet from the surface to bedrock. As a rule there is little gravel in the stream deposits, but occasionally some gravel is found on bedrock.

Most of the placer gold, as on Little and Spruce creeks, is lodged in the sediment that fills the numerous crevices in the shattered bedrock to a depth of 2 to 5 feet. The best concentration of gold, or the pay streak, varies from 20 to 70 feet in width across the rock floor, the wider distribution of gold appearing to be along the lower part of the valley. The pay streak is not always continuous or of uniform richness along the length of the valley. At some places the gold is concentrated more abundantly on one or the other side of the bedrock channel near what are called "rims," which are generally upraised portions of harder bedrock; at other places it is found somewhat restricted to small areas or patches of bedrock; but on some claims the gold is rather uniformly distributed in the shattered bedrock over considerable areas.

Although the placer-gold deposits in Ophir Valley are nowhere more than 35 feet below the surface and may be classed as comparatively shallow diggings, practically all the mining that has been performed along the creek has been done by sinking and drifting with the aid of steam thawing. Mining of this kind has been carried on continuously along Ophir Creek since 1908, in the spring of which year gold in paying quantities was first discovered in this valley. Most of the mining has been accomplished with very crude and inadequate equipment, various kinds of small boilers of the prospecting type being commonly used to generate the steam for thawing the frozen ground. Many of these boilers are of insufficient capacity for effective work. Most of the hoisting from the shafts has been done with homemade wooden hand windlasses operated by one or two men, but recently several operators have installed automatic-dumping steam-hoist equipment.

The largest part of the gold-bearing material is mined during the winter and accumulated on dump piles which are washed for their gold content at the time of the spring thaw. when water is more plentiful than at any other time of the year. The supply of water available for sluicing during ordinary summer seasons is never abundant and during dry periods is often entirely insufficient. At some places sluicing can be carried on during the summer season only after heavy rains and, as such times of increased water supply can not be predicted or depended upon, the amount of gold washing that may be accomplished during a summer is uncertain. Occasionally portions of a summer's output of gold-bearing material can not be washed until the spring after it is mined.

It is no doubt a fortunate circumstance that mining operations on Ophir Creek have not been handicapped by having the placer claims located in the objectionable form of large association groups, whereby the mining privileges to large tracts of land may be dominated by a few individuals, who generally have not the resources or initiative to mine the ground themselves and generally retard mining developments by making unreasonable or even prohibitive demands of those who may wish to mine. All the properties on Ophir Creek are located in the form of single claims of about 20 acres or less, so the interests in mining ground are sufficiently divided to afford opportunities for independent mining to a number of individuals. There are two discovery claims on this creek, a lower and an upper. Eight claims are numbered in downstream order below Lower Discovery claim, and above this claim they are numbered upstream to "No. 12 above Lower Discovery." "No. 12 above" is the same as Upper Discovery, and upstream from this claim the numbers begin again with 1 and extend to the head of the valley.

Productive mining has been done along Ophir Creek since the summer of 1908, on nearly all the claims from "No. 4 below Lower Discovery" to "No. 4 above Upper Discovery," which cover 4 or 5 miles of the middle length of the creek. From 15 to 20 parties have been mining along the valley each year. These parties number from three to ten men each. The larger operators have frequently employed labor, but much of the mining has been done by three or four men working together on a partnership basis.

Ophir Creek has been the largest and steadiest producer in the Innoko district. The output of placer gold from it for the three years 1908 to 1910 totals about $350,000.

YANKEE CREEK.

Yankee Creek is a stream of considerable size and about 12 miles long that lies about 4 miles southeast of the lower course of Ganes Creek. Its valley trends in the same direction as that of Ganes Creek and the other three tributaries of the upper Innoko, upon which placer mining is being conducted. All five of these streams flow from the southwest toward the northeast. The general parallelism of these valleys and the ridges which divide them may be due to structural features of the sedimentary formations of the district, for these appear to extend in a general northeast-southwest direction throughout the region.

Although locations were made on Yankee Creek for placer mining in 1907, gold in paying quantities was not found in its valley until 1909. Most of the mining has been done upon parts of two large tracts located in the form of association-group claims, containing about 160 acres each, situated 6 or 7 miles above the mouth of the creek. The titles to some of this ground became a matter of litigation in court as soon as the land was learned to be of value, the questions involved being whether the first locators, who were not present when gold in paying quantities was found, had not forfeited their rights in the property by abandonment, whether they really knew there was gold on the claims when they located them, and whether they did any assessment work to show their intentions to mine the ground after they made their original locations. The point worthy of notice is that the ground in dispute was located in the form of large association-group claims, so that the litigation involved a large area of land and thus retarded mining developments in a way that would not have occurred if the ground had been located in the form of single 20-acre claims by individuals.

The gold-bearing deposits that are being mined on Yankee Creek differ somewhat from those on Little, Spruce, and Ophir creeks in that they are more shallow, being only about 8 feet deep, and are composed largely of beds of coarse gravel from 5 to 7 feet thick, covered by only 1 to 3 feet of silt and muck. The valley bottom has a fairly broad, flat cross section and its sides have moderate slopes in most places, so the unconsolidated deposits have a uniform depth and considerable width. The stream has a good flow of water and more of a grade than the other placer creeks. The gravel deposits appear to be well drained and largely unfrozen, perhaps because the unconsolidated deposits are not deep, because there is a good circulation of water through the coarse porous gravel, and also because the silt and muck covering the gravels is comparatively thin.

The mining of these shallow placer deposits is summer open-cut work. After the deposits covering the surface are groundsluiced off for a width of about 100 feet the gravels are shoveled into wheelbarrows and then conveyed to a hoist bucket suspended from an overhead cable and elevated to a dump or rock box at the upper end of a line of sluice boxes erected on trestles. The coarser material is forked out of the rock box and the remainder washed through the riffle boxes. The general procedure is the same as that practiced on Flat Creek, in the Iditarod district (see pp. 255–258), but the operations have not been as extensive as those on Flat Creek, partly because some of the ground on Yankee Creek has been tied up by litigation, and also because there has not been an adequate supply of steam hoisting and scraping machinery available in the Innoko district. Only one steam hoisting plant was installed on Yankee Creek in 1910. The other operators were hoisting the gold-bearing gravel to the sluice boxes by hand windlasses.

Yankee Creek first became a producer in 1909, the output for that year amounting to about $15,000. During 1910 from $50,000 to $60,000 was mined. The total production for 1909–10 amounts to about $75,000.

IDITAROD GOLD-PLACER DISTRICT.

OTTER CREEK.

Otter Creek is in reality a small river whose valley has a length of about 30 miles and a width between the crests of its bounding divides of 6 to 8 miles. For the greater part of its length Otter Creek flows near the right-hand side of its valley bottom along the foot of abrupt slopes that rise directly from the stream channel to heights of 500 to 1,500 feet within distances of 1 to 2 miles. At the scene of mining on Otter Creek the floor of the valley is about one-fourth mile wide and the placer claims practically all lie on the left side of the stream. Beyond these claims the left slopes of the valley rise gradually to the divide, 4 or 5 miles distant. The volume of water in Otter Creek is large enough to afford transportation for supplies by means of horse scows and poling boats from Iditarod River to the mines, but the grade of the valley is not sufficient to make this water available for hydraulicking the placer deposits.

The productive gold-placer ground lying along Otter Creek is of comparatively local extent when the length and size of the valley are considered. The present mining operations on this creek are confined to a limited tract of land about 2 miles long and one-fourth mile wide situated in the valley bottom about 12 miles above its mouth. Beginning at the upper limit of known productive ground, the mining claims included within this tract in downstream order are as follows:

The Gum Boot group, which consists of about 60 acres that extends across Otter Creek at the mouth of a right-hand tributary named Granite Creek, lies between claims located on the lower part of Granite Creek and the Otter Association group. The latter group, which is 1 mile long and one-fourth mile wide, extends along the center of Otter Valley Flat, with the mouth of Granite Creek about opposite the middle of its length. These two association groups have been prospected and the conclusion reached that gold in paying quantities does not occur in them above Granite Gulch.

Below Otter Association group there is a row of six single placer claims designated Nos. 2 and 1 above Discovery, Discovery claim, and Nos. 1, 2, and 3 below Discovery. Along the left side of these six claims is another line of similar claims with corresponding numbers and the additional designation "first tier of left-limit bench claims." There is also part of a second tier of left-limit bench claims and several small fractional claims. Altogether these claims cover the width of the valley flat for about 1½ miles along its length. Below No. 3 below Discovery there is a group of claims named the K. P. M. Association.

It is reported that prospects of gold are found as far down Otter Creek as the K. P. M. Association, but it is generally conceded by those who have prospected along Otter Valley that gold in productive quantities, in the sense that is now accepted in the district, does not occur below the vicinity of claim No. 2 below Discovery. Thus the general extent of the productive area on Otter Creek, as now defined, is that part of its valley floor that extends downstream from the mouth of Granite Creek for about 1½ miles. Throughout this area the country rock upon which the gold-bearing deposits rest is composed largely of granitic rocks, the upper parts of which are considerably decomposed and overlain by a layer of residual sands derived from the granites. These sands grade into the solid country rock in many places and as a whole do not appear to be very much washed or sorted by running water. Mixed with them are some gravels and a considerable number of residual granite blocks, bowlders, and cobbles, which are evidently harder portions of the granite that have resisted decay and have not been moved any great distance from their original bedrock source. These deposits hold the placer gold, which also has the same residual character as the material in which it rests in that it consists mostly of sharp, rough, flaky pieces, rather than of smooth waterworn nuggets. Most of the gold occurs in the sands and decayed bedrock. Much of it has sifted down into crevices in the bedrock, where it is present in thin seams of fine sediment that fill these cracks to a depth of 3 to 6 feet. The gold also has a tendency to concentrate more abundantly upon layers of clayey sediment interbedded with the sands and gravels.

The gold-bearing placer beds vary in thickness from 1 to 6 feet. In mining them from 2 to 6 feet of the bedrock upon which the unconsolidated deposits rest is also taken up to recover the gold in its crevices. Covering these deposits is an overburden of sediment and vegetable muck from 4 to 12 feet thick. Altogether the unconsolidated materials of the placer area on Otter Creek have a total thickness of 10 to 20 feet and the placers are classed as shallow. They are in general frozen, but where mining is being done it has been found that the deposits are not frozen throughout and that considerable areas are thawed and wet. This may be caused by the presence in the valley of large quantities of flowing water. Where the gravels are thawed underground water is abundant, but as all the productive mining is done by open-cut methods the presence of flowing water and thawed ground does not hinder working them as it does in deep or underground mining.

FLAT CREEK.

Flat Creek is a southern tributary to Otter Creek, which it joins about 2½ miles below Discovery. It has its source on a wide-topped mountain mass at an elevation of about 1,600 feet above sea level and flows about true north for 5 miles. The elevation of Otter Creek at the mouth of Flat Creek is about 300 feet above sea level, but although there is a difference of about 1,300 feet between the mouth and source of Flat Creek about 1,000 feet of this difference occurs within 1 mile of its head, and the lower 4 miles of its valley has a comparatively low, even grade of about 100 feet to the mile. It is this characteristic of the valley that has suggested the name Flat. This name is also applied to the most important mining settlement in the district, which is located on the south bank of Otter at the mouth of Flat Creek.

The head of Flat Creek valley is a semicircular, steep-sided basin whose catchment area is large in proportion to the size of the valley as a whole, and for this reason Flat Creek has a larger volume of water than is usual for so short a stream.

The body of intrusive granite previously mentioned (p. 245) as extending across the head of Flat Creek occupies practically all of the steep headwater slopes of this valley, or the upper mile of its length, but throughout the rest of the valley, or its lower 4 miles, the softer sedimentary formations of the region occur. Along the zone of contact of the granitic and sedimentary rocks considerable alteration has taken place, and mineralization appears to have occurred in both along a belt of considerable width. Quartz stringers from 6 to 12 inches thick occur in the granites, and the sandstones and shales have been hardened to quartzites and argillites or blocky slates. The hardening of the sedimentary rocks extends as far as a mile from the granite but gradually becomes less with increasing distance from the contact. This contact crosses the upper part of the valley in a diagonal northeast-southwest direction along the lower slopes of its headwater basin, then passes up through a saddle on the divide to the southwest and continues across Happy Gulch, a headwater of Willow Creek, a short tributary of Iditarod River west of Flat Creek. The southwestern end of the Flat Creek granite mass is a short distance southwest of Happy Gulch. Placer gold is found on Happy Gulch and Willow Creek.

The richest gold-placer deposits so far found in the Iditarod district occur on Flat Creek from 3 to 4 miles above its mouth. The bedrock origin of this gold is apparently the zone of alteration and mineralization along the contact of the granites with the sedimentary formations that cross the upper part of the valley. The placer mining claims that include the productive ground are of such irregular sizes and shapes that a general written description, unaccompanied by a detailed plat, can not give an intelligible idea of their location or extent with reference to one another, so individual properties will not be mentioned in this account. The side and headwater slopes of the valley are also covered by claims of various extent and area. About the head of the valley most of the claims are in the form of association groups that contain the equivalents of two to eight single 20-acre placer claims.

In general the prospected ground covers all of the valley floor of Flat Creek from mouth to source, but at present the most active mining development is on the upper part of Flat Creek, from 3 to 4 miles above its mouth. The gold-bearing deposits on this part of the creek are from 10 to 25 feet deep. They are composed largely of gravels, sands, silts, and a considerable number of bowlders, mostly derived from the decomposition and erosion of the granite country rock that forms practically all the headwater slopes of the valley throughout the upper mile of its length. This granite is deeply decayed and its surface is thickly covered with large blocks and bowlders of the same rock, which are mostly residual accumulations of its more resistant portions. Some of these bowlders and slabs are fully 20 feet and a large number are more than 3 feet in their greater dimensions. To travel over these slopes often necessitates stepping from one bowlder to another, as there are many open spaces between them, although for the most part they lie as a closely packed mantle of débris from 5 to 20 feet thick with smaller fragments and cobbles wedged between them, and the slopes are partly covered by sandy soil and turf, on which grow some good spruce timber and dense thickets of alder and willow brush. A large part of the precipitation that falls about the head of the valley sinks beneath this mantle of loose rock and flows down by many underground channels between and under the bowlders, to reappear near the foot of the slopes and form Flat Creek.

Placer gold has been found in paying quantities along the lower slopes of the granite area, where the bedrock is decayed granite and the wash is of granite bowlders, cobbles, and gravels. This gold is, with little doubt, derived from the mineralized quartz veinlets that occur in the granite and where now found is concentrated from the residual granite sands by the numerous small streams that flow down the slopes. The gold is in rough, flaky pieces, some of them attached to angular fragments of quartz that appear as if they may be freshly separated from vein matter.

The richest concentrations of placer gold, however, are downstream from the granite contact, where they rest upon and within the hard, blocky fractured sedimentary bedrock as successive outwash accumulations derived from the numerous small streams of the granite headwater slopes. The sands, gravels, bowlders, and gold have been fed into the upper part of Flat Valley by these small streams and spread out below along its course by the larger combined flow of water. The unconsolidated deposits along the lower 4 miles of Flat Creek become progressively finer in texture downstream. Along the upper part of the valley bottom bowlders, coarse gravels, and sands occur in larger proportion than fine sediments, while in the lower parts of the valley the finer sands, silts, clay, and vegetable muck become greater in amount.

The distribution of the placer gold in the unconsolidated deposits along Flat Creek has apparently occurred in the same order as the deposition of the coarser and finer sediments. The gold appears to be most abundantly concentrated along the upper part of the valley and to become less in quantity and finer in size downstream from its source, the richest placers being located from 3 to 4 miles above the mouth of the creek. This is apparently due to the probable bedrock origin of the gold at or near the contact of the intrusive mass with the sedimentary rocks that cross the head of the valley and also to the fact that the headwater streams flowing over the mineralized granites have gathered and dumped gold-bearing wash into the upper part of the main valley, where the combined drainage loses much of its grade and transporting capacity a short distance below the mineralized contact belt. In consequence of this the ability of the running water to concentrate the gold in the gravels and sands is greater on the upper section of the stream than elsewhere.

On the upper part of Flat Creek the coarse unconsolidated deposits are not overlain by a very thick barren cover of frozen sediment. The transporting power of the creek appears to be sufficient to carry most of the fine sediment farther downstream, for such deposits of silt with vegetable muck become thicker and more widespread toward the mouth of the valley.

The best pay layers in the washed deposits are the lowermost beds of gravels and sands from 1 to 3 feet thick that rest upon the bedrock surface and underlie from 16 to 20 feet of less productive or locally barren material. However, at some places on the upper part of the creek nearly the whole thickness of washed material contains more or less gold, fine light particles of it being found in the soil just beneath the turf. Much of the placer gold is also found from 3 to 6 feet down in the fracture cracks of the hardened sedimentary bedrock, where flaky pieces are embedded in thin seams of fine sediment that have been deposited therein. Without doubt this gold has been sifted down from the overlying sands and gravels by circulating water that has filtered through them into the crevices in the bedrock, the water washing the finer sediment and particles of gold from the sands into the bedrock crevices, where the sediment clogged the spaces and held the gold and the water passed away beneath.

WILLOW CREEK.

Willow Creek is a stream of about the same length and size as Flat Creek and has its source immediately southwest of the head of Flat Creek over a divide about 1,000 feet high. It flows into Iditarod River about 7 miles above Otter Creek. The principal headwater tributary of Willow Creek is named Happy Gulch.

Happy Gulch has its source on the west side of the same broad, gentle slope of the mountain mass on which rise the southern headwaters of Flat Creek, and like them it drains part of the same granite area. The southwest end of this granite mass is only a short distance southwest of the head of Happy Gulch. Along its northwest side the granite is in contact with the same sedimentary formations that occur on lower Flat Creek and these sedimentary rocks likewise form the country rock throughout the lower valley of Willow Creek. The contact between the granite and sedimentary rocks crosses Happy Gulch near its head. In fact, the gulch topography of this tributary begins near this contact and extends downstream as if it may be due to the fact that the sedimentary rocks in which it is cut are more easily cut down by stream erosion than granite. Although the sedimentary formations are softer than the granite, they nevertheless have been hardened to a considerable degree along their contact with the granite. This alteration is the same as that on Flat Creek. The metamorphism gradually diminishes away from the contact and at a distance of a mile the sandstones and shales are of ordinary hardness and texture.

Mineralization appears to have occurred at and near the contact. The granites are deeply decayed, and accumulations of partly residual and partly waterworn granite sands, gravels, cobbles, and bowlders, similar to those on the slopes of upper Flat Creek valley, occur throughout the upper mile of Happy Gulch. Placer gold of the same rough, angular, little-worn appearance as that found on upper Flat Creek, many pieces showing faces of crystalline form, occurs in the granite wash deposits along Happy Gulch where it cuts across the contact belt. The best concentration of gold appears to be in more or less disconnected layers of gravels and sands from 6 inches to 2 feet thick, mixed with bowlders that lie near the bottom of the unconsolidated deposits. These deposits vary from 5 to 10 feet in thickness. Their surface is covered by a growth of moss and turf and dense thickets of willow and alder brush.

A small amount of open-cut, ground-sluice, pick and shovel mining was performed on Happy Gulch during August and September, 1910, on what is named the Summit claim, which is near the head of the gulch and a short distance above the contact of the granite with the sedimentary rocks. This claim is about as far up the gulch as water in sufficient quantity for groundsluicing may be obtained. Even here the adequacy of the supply is largely dependent upon the occurrence of frequent rains on the mountain slopes above. Fortunately these slopes are extensive and of gentle grade, so the run-off is somewhat regular, and by digging small reservoirs enough water may be retained for small mining operations. The granite bedrock on the Summit claim is so deeply decayed that the action of running water quickly erodes down into it, and a ground sluice, if it is allowed to work in one channel too long, readily cuts below the gold-bearing waterworn material that rests on top of the decomposed bedrock.

Placer gold also occurs along the main valley of Willow Creek for several miles below Happy Gulch. The country rocks of this valley are shales and sandstones which are for the most part in a normal unaltered condition; but within a zone which extends out about a mile from the granitic intrusive mass that crosses the upper part of Happy Gulch these sedimentary rocks have been altered and hardened by the deposition within them of considerable quartz in the form of numerous thin veinlets. This silicified condition of the sedimentary rocks appears to be more evident near the contact of the granitic intrusive mass and to become less marked away from it.

The present Willow Creek flows along the north or right-hand side of its valley, in a manner similar to Otter Creek, and cuts into a range of hills to form a line of low rock bluffs. Thus the greatest width of its valley floor, which is about half a mile, lies south of the stream, along its left side. The surface of the valley bottom rises gradually to the slopes of the bedrock ridge that bounds the valley on the south. This ridge separates Willow Creek from a southern tributary named Gold Creek, which joins Willow Creek about $1\frac{1}{4}$ miles below the mouth of Happy Gulch. This ridge between Willow and Gold creeks is composed of sedimentary rocks, and it lies within the zone that has been altered by the quartz mineralization which has apparently been induced by the intrusive granitic rocks that occupy the head of Happy Gulch.

The unconsolidated deposits of Willow Creek valley are largely frozen silts and clays, near the bottom of which are some thin beds of gravels composed mostly of partly worn fragments of the hard-shale country rock. Many of the pebbles in the gravel are angular, as if they had not traveled far enough to be well rounded, and may be derived from a neighboring bedrock source. In places they rest upon and grade by mixture into the broken-up and decomposed hard, shaly bedrock and locally they are mixed with sticky clay. Most of the frozen sediment is a dark-colored carbonaceous material that appears to be largely derived by disintegration from the shaly country rocks. These deposits vary in thickness from 10 to 25 feet. On top of them lies a cover of several feet of mucky vegetable humus and moss.

Some prospecting has been done by sinking and drifting on the claims that are located along the present course of Willow Creek near the low bluffs that border the north side of its valley, but the results obtained have not led to any noteworthy production of gold to date. Along the south side of the chain of claims that extend along Willow Creek from the mouth of Happy Gulch down to Gold Creek there is located an association group of placer ground about a mile long named the Haggerty Bench claim, which occupies practically all of the width of the sloping valley bottom that is not included within the creek claims already mentioned. On the lower end of the Haggerty Bench claim, a short distance above and between the forks formed by Willow and Gold creeks, an open cut about 12 feet deep has been made by groundsluicing to test the value of the deposit. It is reported that this open cut yields about $1.25 to the square foot of surface. The bedrock in this open cut is a shattered hard shale or argillite, commonly called slate, which contains thin veinlets of quartz. The 12 feet of unconsolidated deposits exposed in the cut are frozen silts and clays. The clays are plastic and difficult to wash. The water for groundsluicing this open cut is obtained up Gold Creek by a ditch that brings it upon the upper margin of the sloping bench at an elevation sufficient to furnish enough pressure for hydraulicking the deposits with a canvas hose. It is planned to increase this water supply to about double the present quantity by digging a similar ditch from upper Willow Creek and joining the two ditches on the nose of the ridge that separates Willow and Gold creeks.

The placer gold on the lower end of the Haggerty bench is probably derived from either one of two sources, or possibly from both of them. One source may be the upper part of Happy Gulch, where the presence of gold in considerable quantity is evident, and the other source may be the ridge of altered sedimentary country rock that extends between Willow and Gold creeks from the granitic mass that crosses the upper part of Happy Gulch, although it is not known that the contact-mineralized sedimentary rocks on this ridge are gold bearing. However, if this is the case a concentration of placer gold from the ridge along the south side of Willow Creek valley would be a natural result to expect. In either case the gold that occurs along the south side of the valley appears to have been concentrated in its present position by Willow Creek at a time when it may have flowed nearer the south or left side of its valley. The present position of Willow Creek on the north or right side of its valley gives the impression that the channel of the stream has migrated across its valley bottom from left to right, and even now it is strongly inclined to work northward, as is shown by the low rock bluffs it is cutting along that side.

MINING METHODS.

The mining methods practiced in the Iditarod district may be briefly classified as prospecting and testing, stripping off overburden, excavating the stream-laid deposits and shattered bedrock which contain gold, conveying and hoisting the material to a washing plant, passing it through sluice boxes, removing the angular rock fragments that may clog sluices, and disposing of the tailings.

The prospecting or testing of the placer-gold deposits that have been mined in the Iditarod district is not difficult because they are comparatively shallow, their usual depths varying from 10 to 25 feet. Being shallow, they have been mostly mined by open excavations from the surface. A large part of the ground so far developed is in a thawed condition, but frozen areas of large and small extent also occur. It is only in the frozen areas that underground or drift mining on bedrock may be done satisfactorily, for when thawed ground is opened the water it generally contains is liable to flood underground workings to such an extent that only expensive pumping will keep them free. Even in open pits seepage water often flows so abundantly that it has to be drained into a sump hole and pumped away. The original discoveries of gold in Otter Creek valley were made by sinking small shafts to bedrock, and most of the prospecting of properties preparatory to mining them has been done in this manner. During the winter of 1909–10 a moderate amount of sinking and drifting was done in Otter Valley to test the gold values in the ground, and at one or two localities this method has been continued in a small way during the summer, but in general this kind of work has been handicapped by encountering water in quantities large enough to flood the underground excavations. On the upper part of Flat Creek some prospecting has been done with a steam drill. Some ground was tested near the mouth of Flat Creek and on Willow Creek during the summer of 1910 by groundsluicing or washing out open cuts into the frozen deposits. These frozen deposits are mostly of silts and clays, the frost binder of which, when exposed to the action of air and running water, rapidly disintegrates them into flowing slimes that are removed in suspension by running water. This open-cut work, however, can be done only during the summer, or the season of running water, from May to October, and at localities where sufficient water is obtainable. If prospecting or mining is undertaken during the winter season it must be done by sinking to and drifting along bedrock, and if water seeps into these underground excavations in any considerable amount the work is generally abandoned at that particular place. Sometimes a short distance from a thawed place a solidly frozen spot may be found, where sinking and drifting may be carried on satisfactorily over a small area without interference by seepage water.

Owing to the shallowness of the gold-bearing deposits of the Iditarod and the largely thawed condition of the ground that contains the best values practically all the larger operations so far undertaken have been open excavations from the surface down to and into bedrock. This involves the mechanical removal and handling, in one way or another, of the whole thickness of the unconsolidated deposits and that part of the disintegrated and loosened bedrock which contains profitable amounts of placer gold.

It is generally necessary to remove a variable amount of more or less barren material, such as brush, moss, humus, soil, and silt, from the upper part of the unconsolidated deposits. This stripping off of the barren overburden is done by chopping and grubbing away the vegetation and, if running water is available in sufficient quantity and the grade of the surface favorable, directing one or more streams over the ground by several channels until the surface material is washed away or groundsluiced. If this work can not be done with running water, horse or steam scrapers are used to move the barren material aside. The steam scrapers are similar to ordinary horse scrapers except that they are of larger capacity and are operated by a system of wire cables and steam hoisting engines so arranged that the scoop is filled by drawing it through the earth and then dragged aside to a dumping ground by a cable attached by a pulley to the top of a stout, securely guyed mast, the scoop being then automatically dumped by a tripping arrangement.

After the placer deposits are stripped of the barren overburden it is necessary to excavate and elevate the gold-bearing material into sluice boxes through which it is washed by water to separate the gold from the sands, gravels, and fragmentary bedrock. In the Iditarod placers the bottoms of the valleys are too flat to allow lines of sluice boxes to be set up on the bedrock grades and the gold-bearing material to be shoveled directly into them, as may be done in many placer districts. In order to get sufficient grade to the box lines for washing the gold-bearing material and room to dump the tailings from the lower ends of the sluices it is necessary to erect lines of boxes on trestles from 15 to 30 feet high and to elevate all the gold-bearing material to the upper end of the sluice boxes. The hoisting is done by means of a specially constructed sheet-iron dump bucket attached to a running cable that passes through a combination of pulleys mounted in a carriage which runs along a fixed cable that is stretched across the excavation from the top of a firmly guyed mast. This mast is placed so that the upper end of the fixed cable is suspended above a dump box at the head of a line of sluice or riffle boxes. The running cable is adjusted so that the bucket may be lowered or hoisted at different places in the excavation beneath the fixed cable and drawn along that cable to its upper end near the mast, where it automatically trips and dumps its load on an apron or steeply inclined platform. From this the material slides down into the upper end of the riffle boxes, to be washed through them by a stream of water conveyed to the sluice by a flume, which, like the sluice boxes, has to be elevated on a trestle in order to raise it to the required height.

Steam-boiler equipment varying from 20 to 60 horsepower has been used to operate the hoisting engines at the several plants. This amount of power is considered insufficient by some operators, who intend to install larger boilers in the future. Wood is the only fuel available, and as the supply is none too abundant or convenient it forms a considerable item of expense.

With the exception of the steam hoisting and scraping of the unconsolidated deposits as described above, practically all of the work of mining is accomplished by manual labor, from 10 to 60 men being employed in and about the different excavations according to the magnitude of the operations undertaken. Most of the men work in the open pits digging up the gold-bearing material with picks and shovels and conveying it to the hoist buckets in wheelbarrows. Several men are generally required at the sluice boxes to keep the water and gold-bearing material properly passing through them. Most of the larger angular pieces of bedrock are not allowed to go through the riffle boxes because they are liable to become wedged and clog them. To avoid obstructing the boxes with this angular rock material it is forked out near the head of the sluice after the gold-bearing sediment attached to it has been washed off either by the sluice water or by a stream of water from a hose. The rounded gravel, sand, and silt is washed through the boxes and allowed to stack up at their lower end as tailings. Generally the sluice boxes are erected high enough above the ground to afford space for the disposal of the tailings by gravity, by occasionally changing the arrangement of the boxes, but in some places the tailings must be moved aside mechanically by a scraper or hoist to prevent blocking the dump.

MINING COSTS.

The mining operations conducted in the Iditarod district during 1910, the first year of its development, can not be considered normal, because the district has suffered from the effects of many conflicting conditions such as often attend the opening of a new part of Alaska that is comparatively easy of access. The first year or so of the development of a new placer gold district in Alaska is generally a period of more or less confusion and uncertainty for both the mining operations and the dependent commercial activities. This is probably more pronounced in the Alaskan gold placers because there the natural conditions are more severe than in most other countries.

When placer gold is discovered at a new locality in Alaska, if a general opinion that the district offers considerable mining promise gains popular acceptance, the movement of population to the new locality during the first years of its development is often out of all proportion to its gold-productive possibilities. A condition of overpopulation has characterized the early history of many of the placer-gold districts of Alaska, especially those which are fairly accessible by summer routes of water transportation, and this condition often continues until a district has passed its period of maximum development. On the other hand, districts which are sufficiently removed from steamboat transit to be difficult to reach are seldom overpopulated, and the mining development of such districts to their full possibilities generally lags for want of sufficient supplies and equipment. This prevents the exploitation of deposits which in more accessible localities could be mined with a profit that would sustain a considerable population.

As a rule the mining and commercial activities of an Alaskan placer-gold district, although closely interrelated and intimately dependent upon each other, are rarely in economic harmony. This lack of adjustment often continues throughout the history of a district and is directly reflected in the cost of mining. In most places, especially in the interior of Alaska, transportation is a primary factor governing mining development and is of most vital importance, a high cost of mining generally being chargeable to the lack of cheap and satisfactory facilities for the conveyance of ample supplies from the United States to the placer-gold districts. The mining industry is largely controlled by this factor, for no matter in what part of the Territory mining is undertaken the problem of transportation enters as a primary influence in determining the relation of the mining costs to production, and the difficulty or ease with which a particular locality may be supplied with the food, clothing, implements, and machinery required by a mining population determines the possibilities of exploiting deposits of different values. Practically all these supplies are obtained ready-made from the United States, and the freight charges for their carriage to points on the water routes of transportation, especially in the Yukon Valley, are considerable. The cost of transportation, however, is generally much increased before the supplies reach their final destination, for in most cases it is necessary to move them from 5 to 50 miles overland and the cost of this, especially for large or heavy pieces, such as boilers and hoists, increases enormously with the distance.

Probably it will never be possible to obtain the data necessary to present a complete analysis of the commercial mining condition of a placer-gold district in Alaska, especially for the first years of its development, because reliable evidence in the form of accurate figures is rarely obtainable. Some of the more systematic operators keep business accounts, but a great amount of placer-mining work is done without keeping records of the costs. The few statements of costs available show that the cheapest mining in the Iditarod during 1910 cost 22 per cent of the production of a particular operation. Another comparatively low-cost operation was performed for 32 per cent of the production. These costs are the lowest reported. On the other hand, much of the mining so far done has cost 70 per cent or more of the production. The general average cost of mining in the district for the season of 1910 probably was between 50 and 60 per cent of the total production. The cheapest operations are much below the average of the district and are probably nearly as low as will ever be accomplished by the methods used. Although costs may be reduced if conditions become better balanced, such results probably will be attained only upon small tracts of favorably situated ground. The deposits mined at the lowest costs cited above are about 10 feet deep and rest upon a soft bedrock of deeply decomposed granitic rock that may be readily scraped up and very easily washed after an overburden of muck and silt is removed by groundsluicing. The actual cost of mining this deposit was about 28 cents per cubic yard. This is as low as the cost of some dredge mining on Seward Peninsula, where the lowest cost of placer-gold dredging so far attained is 18 cents per cubic yard. In the Iditarod district it will cost considerably more to install and operate dredges than on Seward Peninsula, as transportation and fuel will be far more expensive, so it is doubtful if dredge mining can be conducted in the Iditarod for 18 cents per cubic yard.

The possibility of placer-dredge mining on considerable tracts of the flat-lying stream deposits that cover the valley floors of Otter and Flat creeks, which are presumed to be gold bearing to a greater or lesser degree and extent, has been discussed in a preliminary manner by some of the persons interested in ground on these creeks. Such an enterprise should not be undertaken without first securing a satisfactory community of interests for considerable tracts of placer ground and prospecting them thoroughly enough to determine the extent and thickness of the gold-bearing beds, so as to enable reliable estimates to be made of the amount of gold that occurs, with known quantities of the material to be handled by a dredge, including the barren overlying deposits with which the gold-bearing material is associated. Due allowance must also be made for the difficulties that may be encountered by dredge buckets in digging up the shattered bedrock, in the cracks of which much of the gold lies, and also in handling the bowlders which are present in the Iditarod deposits in considerable numbers. Experienced dredger men should be consulted before such an investment is made.

PRODUCTION.

Commendable energy has been shown by the real mining element of the Iditarod district in overcoming the obstacles the mining situation presented to them; for the camp, so far, never has promised to produce enough new wealth to satisfy even the reasonable expectations of all the people who have interested themselves in the district in various ways. Before June, 1910, very little was definitely known about the occurrence of the placer gold and there was not an adequate supply of mining equipment at hand with which to work, but after the season opened no time was lost in commencing operations which would demonstrate the mining possibilities of the district. The necessary boilers, hoists, etc., with which to perform effective work were brought to the head of steamboat navigation on Iditarod River and thence moved with considerable difficulty and expense to the better-known placer tracts on Otter and Flat creeks, where they were quickly installed and actively operated without delay until the freeze in October.

When it is considered that the district has been greatly overpopulated by a class of persons whose intentions are not to mine but to gain indirectly from the results of the miners' labor, the first season's gold production has been as large as could be expected. Of the 2,500 persons who entered the Iditarod district during 1910 not more than 1,000 engaged in work directly related to its mining development. The remainder, or much over half of the population, had no other intentions than to engage in parasitic pursuits of minor importance to mining, and it is probably unfortunate that the district has been thus overburdened, especially by so many persons who have shown over-enthusiasm in town-site booming and kindred speculative enterprises.

The gold output of the Iditarod for 1910 amounts to about $500,000 in value, of which about $200,000 may be credited to Otter Creek and the remainder, $300,000, to Flat Creek. There was also a few thousand dollars' worth of gold mined from Black and Willow creeks in the course of preliminary development work.

OUTLYING PLACER-GOLD LOCALITIES.

The one significant result of the overpopulation of the Iditarod has been to stimulate a widespread search for placer gold throughout the surrounding territory, particularly south of the present center of mining on the headwater branches of large streams that flow into Kuskokwim River from the divide that separates them from the Iditarod drainage. The results of this movement, which during August and September, 1910, was participated in by over 500 men and reached the magnitude of a "stampede," indicate that prospects of placer gold occur in several areas of moderate extent within the valleys of Moore, Jualin, Donlin, and Crooked creeks, which are south of and opposite the headwaters of Otter and Bonanza creeks. Prospects are also reported to occur on Little Creek, a tributary of Iditarod River about 75 miles above Otter Creek. Although there appears to be little doubt that some prospects of placer gold have been discovered at particular spots of small extent on several of the smaller tributaries of the streams named above, it is not possible at this time to make any definite statements about the extent or richness of these new gold-bearing areas. The men who participated in this stampede movement did not apply their energies toward making or verifying discoveries of placer gold, but, after the manner now commonly practiced all over Alaska in such cases, they devoted practically all their time to traveling rapidly over the country and hastily placing location stakes and notices so as to embrace vast tracts of land for placer mining without making any effort to determine its gold-bearing character (a primary requisite of the law), simply assuming that placer gold may possibly occur in some of the ground located from the meager fact that there may be an actual occurrence known within several miles, perhaps in the same valley or some adjacent basin. Oftentimes, however, not even this small stimulus is considered essential, the optimistic imagination characteristic of the gold seeker being enough to make him think that, to use the common expression, "the country looks good." Indeed, the custom of making wholesale locations of land in the form of countless association-group claims of 160 acres each, for the ostensible purpose of placer mining, has become so general throughout Alaska during the last four or five years that it is now unusual in many districts to find ground located as single 20-acre claims. It is not uncommon for several men in partnership or even one individual, sometimes provided with powers of attorney of a number of absent persons, to claim by priority of location from 25 to 50 and occasionally as many as 100 association-group claims of 160 acres each—in other words, to make ridiculous claims of intentional mining rights on 50,000 to 150,000 acres of the public domain. The manner in which this practice appears to be countenanced by Alaskans gives ground thus falsely claimed a sort of concessionary value that is considered as an asset, by which claimants hope to profit if by chance a genuine discovery of gold is eventually made upon or near some of their illegal holdings. It is a matter of common knowledge throughout Alaska that no actual discoveries of gold are made on 90 per cent of the claims staked when they are first located for placer mining. The apparent purpose governing the whole matter is to first get what is considered a prior control of large tracts of land with the idea that gold may be discovered upon some of it afterward, which discovery may then be turned to the financial advantage of the persons who claim priority of location but who have done nothing to deserve reward. In brief, the primary object of the mining laws, whose intent is to encourage citizens to search without restriction for mineral wealth upon the public domain and, if they actually discover it, to protect their rights as individuals therein as long as they give evidence of reasonable interest in the exploitation of such mineral wealth, is utterly ignored. The exploitation of Alaska's placer deposits at the present time is apparently suffering from the chaotic condition brought about by an utter contempt for both the mining laws and the common rights of the public in the matter.

Popular opinion throughout Alaska seems to strongly denounce the abuse of the locating privilege by the unrestricted use of powers of attorney and association-group staking. The personal opinions expressed by most individuals are to the effect that such methods should be abolished, yet they do not intend to deny themselves such privileges as long as they have no guaranty that others will not take advantage of them.

CONCLUSION.

At present it is not possible to make conclusive statements regarding the future mining possibilities of the Iditarod district. During the summer of 1910 enough experience was acquired with the placer deposits on Otter, Flat, and Willow creeks to define fairly well the character of the unconsolidated stream deposits where mined and the conditions surrounding the occurrence of the placer gold in them. The work performed shows that there is a general similarity in the kinds of unconsolidated deposits on these three streams, but there are some variations in the relative proportions of the finer and coarser materials, in their thickness, and in the presence or absence of perpetual frost. All the deposits belong to the class of shallow placers, which may be best mined by open surface excavations.

Though considerable prospecting has been done to determine the extent of the placer-gold deposits and though their limits of distribution on Otter, Flat, and Willow creeks seem to be well defined in some directions, it can not be stated now with any degree of certainty how extensive they may be or how much gold they may contain. It may be said, however, that the mining situation on these three creeks is well in hand and without doubt will soon adjust itself to the conditions surrounding the occurrence of the placer gold. No doubt more ground may be mined with a profit in the future than would have been possible under such conditions as were prevalent during 1910.

From what is known of the occurrence of placer gold in the Iditarod and the adjacent districts of Innoko and Tuluksak it appears probable that there may be other similar but separate areas of auriferous mineralization of moderate extent distributed in a more or less scattered manner throughout the central part of the Kuskokwim Mountains. In this province the indications seem favorable for the discovery of gold-bearing stream placer deposits at or near mineralized zones of contact of granitic intrusive rocks with the sedimentary formations. These areas, however, do not appear to form a continuous gold-bearing belt.

The probable future expansion of placer mining in this region will depend chiefly upon the discovery of more occurrences of local gold-bearing mineralization in the vicinity of intrusive masses or dikes of granitic rocks such as are known to occur at several places along the Kuskokwim Mountains from the headwaters of the Innoko and Tuentna on the northeast to the Tuluksak on the southwest. At this date several new gold-bearing localities of this kind are reported.

Those nearest the Iditarod on Jualin, Donlin, Crooked, and Little creeks have attracted the most attention, but portions of the valleys of Moore Creek, a headwater branch of the southwest fork of the Takotna, and of the large northeast branch of this river, which is called the Tuentna or Nixons Fork, have also aroused enough interest to be extensively located upon in the customary wholesale manner for placer mining. The results of prospecting that will be carried on at all these new localities during the present year will be very important in determining the extent and activity of placer mining throughout the Kuskokwim Mountain region.

Northward from the Innoko district the Kaiyuh Mountains may prove a good field for prospecting, because granitic intrusive rocks similar in lithology to those that appear to have brought about the auriferous mineralization of the Innoko and Iditarod districts are known to occur there at many localities.

THE SHUNGNAK REGION, KOBUK VALLEY.

By Philip S. Smith and Henry M. Eakin.

INTRODUCTION.

In the central part of the Kobuk River basin there is a mineralized area in which placer gold has been mined and copper, gold, lead-silver, and asbestos deposits prospected. These deposits had not been studied by members of the Survey before 1910. The region was the scene of a stampede of gold seekers in 1898, but although a few thousand dollars in gold was produced annually for several years, in 1910 the district was nearly deserted. Many problems of importance both to the prospector and to the geologist still remain to be solved by more careful examination, but until such studies are made it has seemed expedient to set forth the general geologic observations and to point out some of the important subjects that require further investigation.

The region considered in this report lies north of the Arctic Circle, adjacent to the 157th meridian. Particular attention is given to the region between Kogoluktuk River on the east, Shungnak River on the north and west, and the Kobuk on the south. Although this small area is the place where minerals of economic importance have been found and is directly the subject of this report, a somewhat larger region is described in order to show the setting or general relation of this field to the geology and geography of the central part of the Kobuk Valley. A still broader and more comprehensive account of the features of northwestern Alaska is in preparation and will serve to extend the area covered by this more detailed report.[1]

GEOGRAPHY AND TOPOGRAPHY.

Figure 19 shows the general location of the area, which for convenience will be called the Shungnak region. The settlement from which this name is taken is about 250 miles from the mouth of the Kobuk, measured along the crooked course of the river. Measured

[1] Smith, P. S., Geology and mineral resources of northwestern Alaska; in preparation.

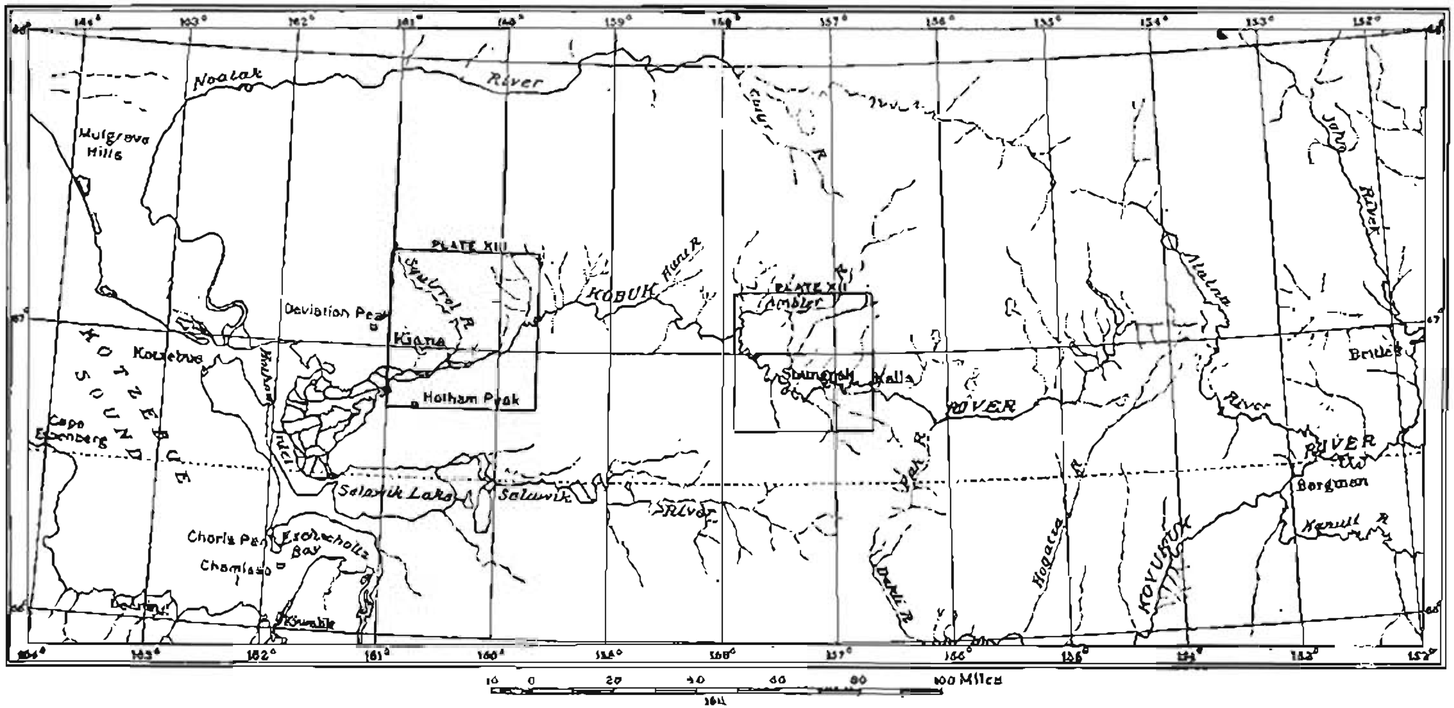


FIGURE 19.—Sketch map of part of northwestern Alaska, showing location of Shungnak and Squirrel River regions.

in a straight line, however, it is only a little more than half that distance. Throughout this distance the stream is navigable for boats drawing as much as 3 feet, and an even greater draft could be carried if it were not for shallow bars at the mouth of the river and the crooked, shifting course of the channel farther upstream. The best approach to this region is by way of Kotzebue Sound and Kobuk River, for a mail boat from Nome touches at Kotzebue three times a month, and launches and barges can be taken there for points up the river. A description of the method of reaching Kiana, at the mouth of Squirrel River, is given on pages 306–309 and applies to reaching Shungnak as well, but the river trip continues for another 175 miles and consequently takes from 5 to 10 days longer. In 1901 Mendenhall reached this region by way of Koyukuk and Alatna rivers, and this route has been traveled by natives and prospectors for many years. This is, however, a roundabout way of reaching Shungnak and is not suitable for bringing in supplies, etc. In 1910 the writers reached the region by going overland from the Koyukuk near the mouth of the Hogatza, but this is not a direct route and is not a feasible way of reaching the Kobuk except during the winter months.

RELIEF.

The larger-scale map (Pl. XII) shows more details of the Shungnak region than are given on the sketch map (fig. 19). Although the topography of the map shown on Plate XII is in a measure obscured by the patterns used to denote the several geologic formations and groups, the major features of the relief are evident. From this map it will be seen that there are five more or less distinct belts of relief. The most southern of these belts is a range of hills, averaging about 2,000 feet in elevation, succeeded toward the north by the Kobuk Valley Flats. These are in turn succeeded by a narrow range of hills reaching heights of about 3,000 feet in the eastern part and gradually decreasing in altitude toward the west. North of these hills is a lowland 3 to 4 miles wide which is succeeded toward the north by rugged mountains.

The southern hills, called by Mendenhall in 1900 the Sheklukshuk Range, form only a narrow highland between the Kobuk lowland and the Selawik lowland on the south. These hills have been only slightly explored, but they are probably not more than 10 to 15 miles wide and trend in a general east-west direction. The higher points reach elevations of 4,000 feet, but the average elevation is only about half as great.

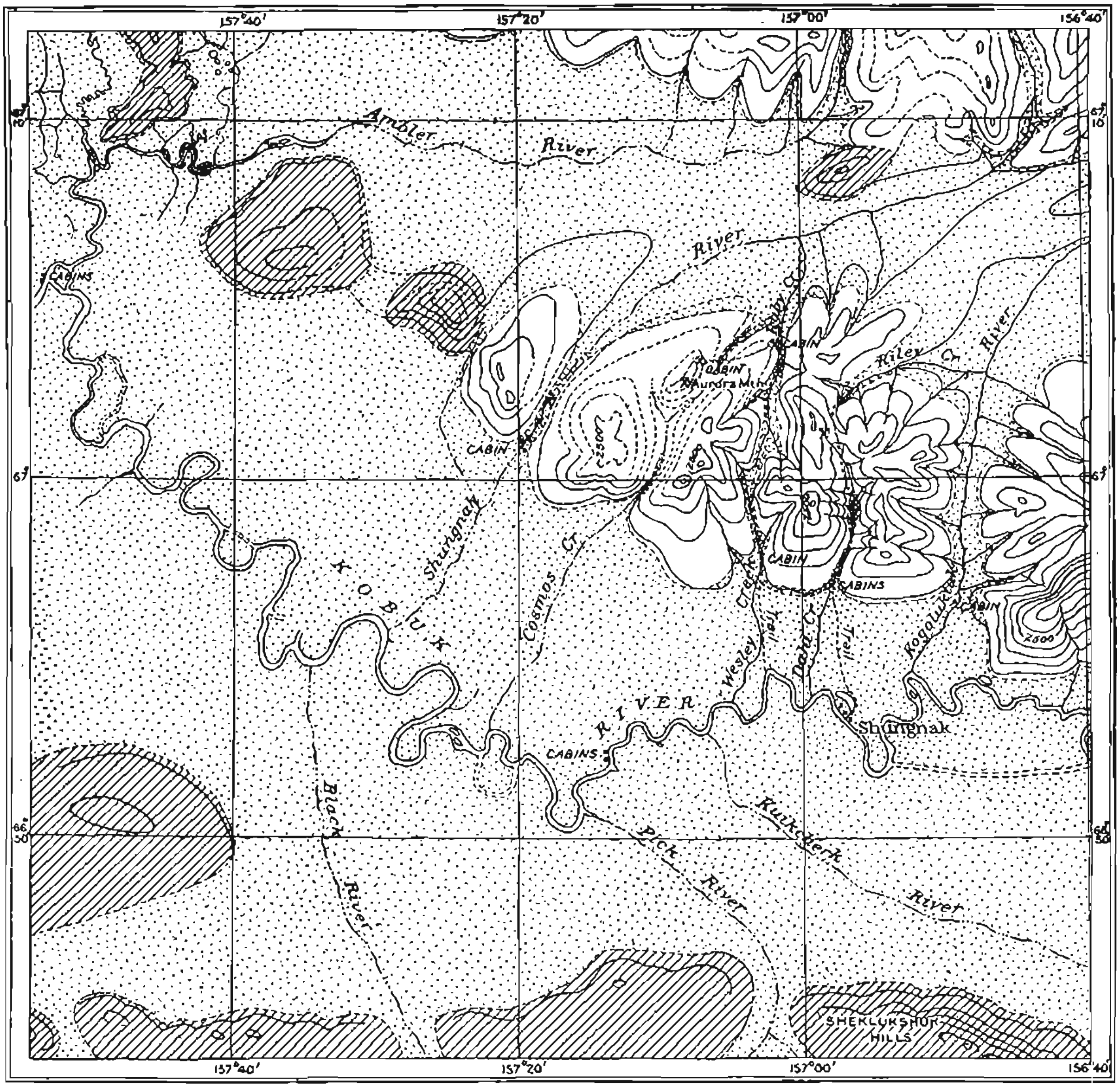
The Kobuk lowland, so called from the large river which traverses it, is from 10 to 15 miles wide and has an average elevation of 200 to 400 feet above the sea. The highlands which bound this lowland to the north and south rise rather abruptly from the nearly featureless plain and emphasize by their sharpness the plain's slight relief. The flood plain of the Kobuk occupies a width of several miles along the central part of the lowlands, distinguished by the occurrence of numerous bayous and crescentic lakes marking former courses of the river. The higher parts of the lowlands on either side slope from the bordering hills toward the river, descending to the slightly lower level of the flood plain with more or less distinct bluffs. The surface of such parts of the lowlands is not altogether smooth, as locally there are lakes of irregular shape and small size.

North of the Kobuk lowland, as already noted, a range of hills, in places 3,000 feet or more in height, rises abruptly and forms a strip of highland 10 to 12 miles wide toward the east but gradually narrowing toward the west as it approaches the junction of the Kobuk and the Ambler. No name has been given to these hills, though they appear to be the continuation of Lieut. Stoney's Schwatka Mountains.[1] Owing, however, to the misconception that existed as to the general topography and to the fact that the name as applied does not separate this front range from the main range to the north, it has been proposed to call the feature above described the Cosmos Hills. This name is given because Stoney's winter camp on the Kobuk was called Fort Cosmos and the stream near his camp, which heads in these hills, was also called by this name. These hills are characterized by a general east-west trend but are considerably dissected, so that the higher points are irregularly distributed.

Beyond the Cosmos Hills is a lowland not so extensive as the Kobuk lowland but still a marked topographic feature. To the west this lowland is drained by Ambler River, but to the east it is traversed by Shungnak and Kogoluktuk rivers and it persists even farther east, if scattered observations and reports are to be trusted. Even where it does not contain a large stream this lowland is still preserved and it is believed to be a significant structural feature. A particularly clear illustration of a portion of the lowland without existing streams is shown by the area between Ambler and Shungnak rivers. At this place the distance between the two streams is about 3 miles and the elevation of the divide between the two is not over 200 feet. In order to have a short descriptive term for this feature it will be called the northern lowland.

North of the northern lowland the mountains rise steeply to heights of 3,000 to 4,000 feet above the main streams, so that their relative relief is strong. Only the southern margin of these mountains is included within the mapped area. From a study of Stoney's map it is evident that this highland belongs to the group of hills named by him the Baird Mountains, and by this name they will be

[1] Stoney, G. M., Naval explorations in Alaska, Annapolis, 1900, map.



5 0 5 10 Miles

Contour interval 500 feet
1911

LEGEND

- Sand, gravel, and silt, fluviatile, lacustrine, and glacial origin
- Mesozoic-Tertiary rocks Sandstones, conglomerates, and shales
- Metamorphic complex Schists, limestones, slates with some sheared igneous rocks
- × Placer
- ⚒ Lode prospect

GEOLOGIC SKETCH MAP OF SHUNGNAK REGION.

called in this report. Serrate crest lines and deeply intrenched valleys characterize these mountains and give a rugged, inhospitable appearance to the landscape.

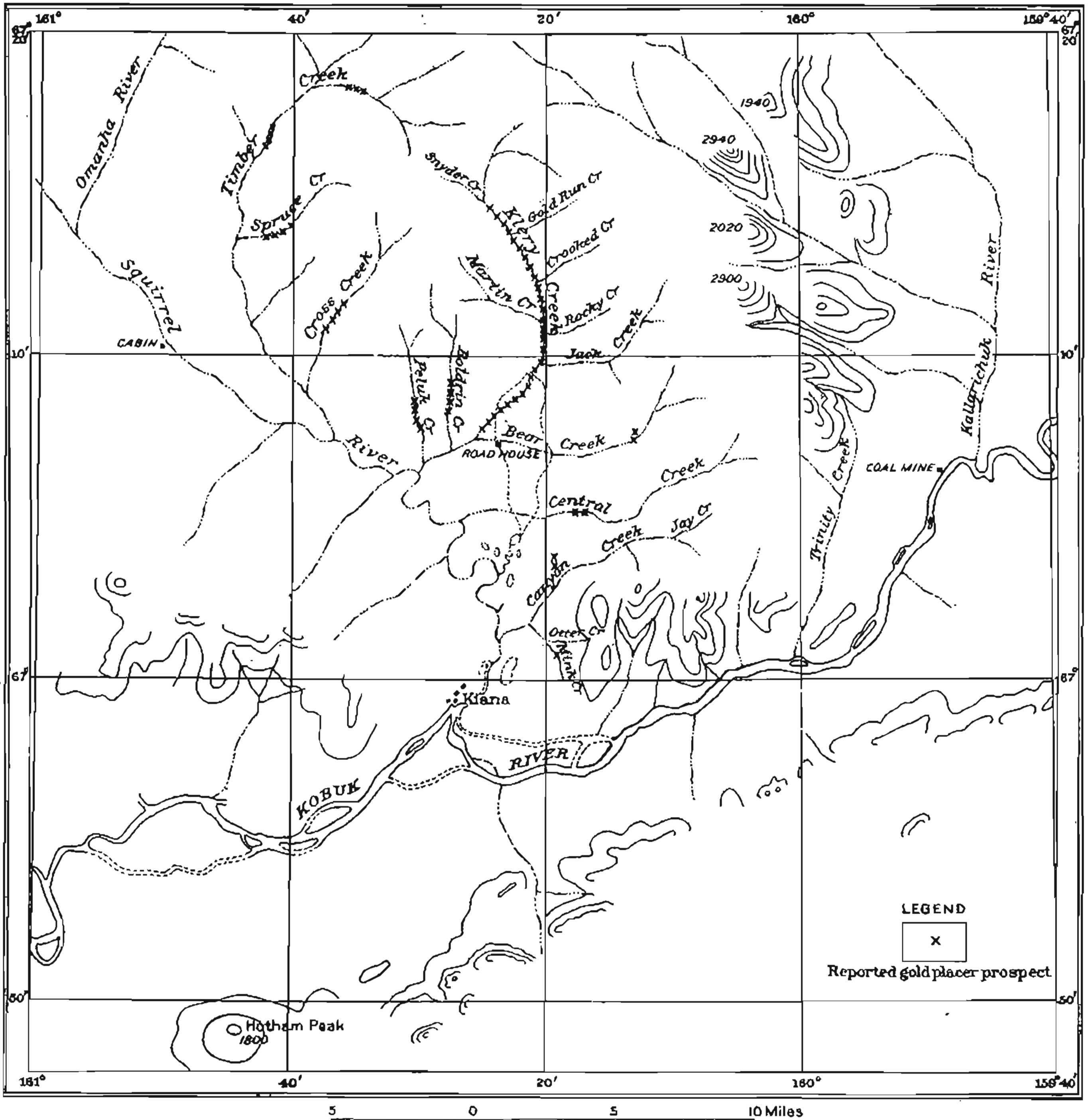
DRAINAGE.

The drainage of the Shungnak region presents a number of different types of streams, many of which have a complex history. The master stream is the Kobuk, which heads in the hills far to the east and flows westward, receiving tributaries that head in the highland areas along its course. The Kobuk is a large river, having a width near Shungnak of 600 to 800 feet and a current of 2 to 4 miles an hour; the depth varies, being in many places as much as 15 to 20 feet. It has a meandering course through the lowland and many of its deserted channels form sloughs and oxbow lakes. The strength of the current is sufficient, however, to make it an easy river to descend, and above the delta even one unfamiliar with the river finds little difficulty in avoiding blind channels. Within the mapped areas there are no rapids or treacherous stretches.

Kogoluktuk, Shungnak, and Ambler rivers are the largest tributaries to the Kobuk from the north. All these streams head in the Baird Mountains and flow in glacially sculptured valleys, receiving many tributaries until the southern face of the mountains is reached. Thence they traverse the northern lowland and then flow in rocky canyons through the highlands of the Cosmos Hills, later traversing the Kobuk lowland to join the main stream. This course, transverse to the dominant geologic structure and also to the topographic structure, indicates the complex history that made such drainage possible. Some suggestions as to the origin of this peculiar drainage are given on page 287, where the course is explained as in large measure due to glaciation and structure.

All these streams carry large volumes of water during the early spring and summer and with the exception of the easternmost are not fordable during ordinary seasons. Owing to their heading in the high mountains they derive a large amount of water from melting snow and so maintain a more constant flow than the streams not having a similar supply. In the highlands their courses are comparatively straight, but in the Kobuk lowland some of them meander in irregular curves. Low falls and rapids occur on these streams as they traverse the Cosmos Hills; in fact, the name Kogoluktuk is said to mean in the native language "river with falls."

The larger streams entering the Kobuk from the south have not been explored, and little is known of their geography except from the reports of natives. Kuikcherk, Pick, and Black rivers are the three largest streams, and probably all of them head in the Sheklukshuk



SKETCH MAP OF SOUTHEASTERN PART OF SQUIRREL RIVER BASIN.

Range. They are smaller than the northern tributaries because they drain smaller basins and also because the lower hills in which they head are not so effective in snow storage as the higher Baird Mountains to the north. In their lower courses these streams are rather sluggish and their water is in large measure derived from the tundra through which they flow. The dark swamp water is suggested by the name Black River, given by Stoney in 1886 to the westernmost of these streams.

In addition to the larger tributaries there are many smaller streams originating in the highlands and entering the main stream independently or joining one of the larger branches. The streams from the Cosmos Hills show many intricacies, as they join the transverse-flowing streams, such as Kogoluktuk and Shungnak rivers. Thus many streams heading on the north side of these hills flow northward to the northern lowland or a transverse stream, where they turn abruptly and cross the range and thus enter the Kobuk. One of the best examples of this feature is Ruby Creek, which heads within 3 to 4 miles of the Kobuk lowland but flows northward for 7 to 8 miles before joining the Shungnak; thence its waters are carried southwest for about 20 miles before reaching the Kobuk. This condition prevails in spite of the fact that near its head there is to the south a pass not over 400 feet above the Kobuk, which has evidently been occupied by former drainage.

Passes similar to the one described at the head of Ruby Creek, although at somewhat higher elevation, are found at the head of many of the other streams. For instance, Cosmos Creek heads practically on the southern slopes of the northern lowland but flows southward across the range to join the Kobuk. These examples serve to show that many of the valleys through the Cosmos Hills have been eroded by agencies other than the existing streams and that the present rivers have had their courses in large measure determined by this earlier topography. It is believed that these passes and transverse valleys are best explained not as due to antecedent streams which persisted or failed to cross the Cosmos Hills during the possible deformation of the region but as due to drainage modifications induced by glaciation in the Baird Mountains and contiguous territory in comparatively recent time.

CLIMATE.

There are but few data as to the meteorologic conditions prevailing in the Shungnak region, though there are more observations here than in other parts of the Kobuk Valley. Mendenhall summarized the available temperature observations as follows:[1]

[1] Mendenhall, W. C., Reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska: Prof. Paper U. S. Geol. Survey No. 10, 1902, pp. 54-55.

Summary of temperature observations on Kobuk River, 1885–1899.

Date	Minimum.	Maximum.	Mean.	Authority.
1885.				
July	32	70	49	Lieut. Stoney.
August	32	68	47	Do.
August	35.5	68	48	W.L.Poto, U.S.Geol. Survey.
September	5	69	39	Lieut. Stoney.
October	−4	46	16	Do.
November	−44	15	−9.5	Do.
December	−65	29	−12.4	Do.
1886.				
January	−70	31	−12.4	Do.
February	−65	26	−22.5	Do.
March	−38	36	−3.8	Do.
April	−22	49	13	Do.
May	14	65	35	Do.
June	32	74	49	Do.
1898.				
July			57.6	McElwaine.
August			50.15	Do.
1899.				
February	−67	10	34.27	

As the mean annual temperature of the region is far below the freezing point, the presence of ice exerts an important control on the length of time that placer deposits can be worked. Snow may be expected in the highlands during almost any month of the year. According to Cantwell [1] the hills west of the Ambler were snow covered on August 9, 1885, and in 1910 the hills above 2,000 feet in elevation east of the Kogoluktuk were covered with snow on July 20. In 1885, according to Stoney, [2] ice had formed on most of the small streams by September 23 and along the main streams by the 25th. By October 18 the main river was frozen so that it could be crossed. Freezing continued until in February the ice had a maximum thickness of 5⅓ feet. On May 19, 1886, the ice along the banks of the Kobuk began to crack, and by June 6 of that year the river was free of ice. Joseph Grinnell,[3] who spent the fall of 1898 and the spring of 1899 a little west of the Shungnak region, reported that on October 15 the Kobuk was full of ice and by the 21st the ice was a foot thick. In the following spring the ice began to break on May 24, and by the 31st the river was free. It should be noted, however, that while the river itself breaks by June 1, Kotzebue Sound remains frozen until the first week or so of July, and therefore communication with the outside world is seldom established before the later part of July or even the first of August.

No instrumental determination of the precipitation is available and but few observations even as to the number of rainy days have been made. W. L. Poto,[4] a member of the Mendenhall party, is

[1] Cantwell, J. C., Exploration of the Kowak River, Alaska: Report of the cruise of the Revenue Marine steamer *Corwin* in the Arctic Ocean in the year 1885, Washington, 1887, p. 47.

[2] Stoney, G. M., Naval explorations in Alaska, Annapolis, 1900.

[3] Grinnell, Joseph, Gold hunting in Alaska, Chicago, D. C. Cook Publishing Co., 1901, pp. 79–84.

[4] Mendenhall, W. C., op. cit., p. 55.

quoted as recording 15 rainy days during August, 1885, and McElwaine[1] reported for June, July, August, and September, 1898, 16, 11, 18, and 12 rainy days, respectively. During 1910 the authors were in the Shungnak region from July 22 to August 11, inclusive, and the number of rainy days and duration of precipitation were as follows:

Precipitation in the Shungnak region, July 22 to August 11, 1910.

July 22	Showers and rain.
July 24	Rain in evening.
July 25	Rain all day.
July 26	Rain all day.
July 28	Mist and rain; heavy rain in evening.
July 29	Rain.
July 30	Heavy mist in morning.
Aug. 2	Rain.
Aug. 3	Rain in morning; showers in afternoon.
Aug. 4	Heavy mist and rain.
Aug. 5	Rain and heavy mist.
Aug. 6	Rain.
Aug. 7	Rain.
Aug. 8	Threatening in morning; cleared later.
Aug. 9	Rain all night; foggy in morning; showers in afternoon.

From this it will be seen that of the 21 days spent in the Shungnak region 15 were marked by showers or rain. It should, however, be noted that last year was exceptionally wet, and therefore the figures by no means represent average conditions. There is, on the other hand, little room to doubt that most of the precipitation comes during the summer, so that July and August are usually the wettest months

VEGETATION AND ANIMALS.

Owing to its high northern latitude the Shungnak region has a typically subarctic flora. Timber is found mainly along the larger streams and does not extend on the mountain sides to any considerable elevation. Spruce and birch are practically the only trees that grow to sufficient size for lumber, and only spruce is large enough for cabin logs or sluice boxes. Stoney[2] notes that the largest spruce tree seen by him in the whole Kobuk Valley was near Cosmos Creek. It measured 80 inches in circumference at the base and 68 inches at a height of 6 feet above the ground and was 80 feet tall. This was an unusually large tree, however, and the average spruce does not exceed a foot in diameter. In the higher parts of the region even spruce is wanting, and the prospector is compelled to resort to scrubby willows and alders for fuel.

Berries are exceedingly abundant on the unforested slopes of the highlands and on many parts of the lowlands. Blueberries are

[1] Mendenhall, W. C., op. cit., p. 54.

[2] Stoney, G. M., op. cit., p. 83.

particularly plentiful on the higher parts of the Kobuk lowland where trees and bushes are absent. Salmon berries are found on all parts of the lowlands and are so plentiful that people and animals depend on them for food. Some currants and cranberries were seen, but they are not as abundant as the two other kinds of berries.

Grasses for stock are found on the lower hill slopes and on the surface of the lowlands. Mendenhall[1] notes rye grass, blue grass or redtop, and a variety of bunch grass as the more usual species. Horses show a strong liking for the so-called goose grass, an equisetum, but it seems to contain little nourishment. The grasses flourish particularly in the neighborhood of the old settlements and camps and quickly spring up in the burned-over areas. None of the grasses seem to stand frost well and all appear to wither and lose their strength-giving qualities as soon as freezing nights begin. This is probably due to their exceedingly quick rank growth.

There are but few game animals now in the Shungnak region except bear. These are found mostly back in the hills or along the unfrequented streams. Both black and brown bears are reported. Caribou have been shot at several places within the region, but they are not numerous and the natives have to travel far to obtain their supply. There is, however, a herd of reindeer in the Sheklukshuk Hills and strays from this herd have probably been taken for wild caribou. Small fur-bearing animals, such as fox, mink, and marten, are occasionally caught, but they are found in no great numbers and are becoming scarcer each year.

Fish are abundant in almost all the streams. Salmon is one of the most important food supplies. These fish are particularly abundant in the Kobuk and during the last week of July and the early part of August native fishing camps are established at several places, especially just above the mouths of Kollyoksok and Black rivers. A large white fish, known to the natives as "she," is also caught in the Kobuk and is much prized for food. Grayling can be found in almost all the side streams and mountain brooks. Trout, probably salmon trout, weighing as much as 3 or 4 pounds each were caught in Dahl Creek and are reported from many of the other streams.

Many birds are found in the Shungnak region. Most important for food are ptarmigan, spruce hens, and ducks. Owing to the cold climate these can be kept for months during the winter without spoiling. Beside these game birds many song and other birds are either summer visitors or live permanently in the region. Grinnell[2] gives a list of the birds wintering in the region near the mouth of the Ambler, noted by him, as follows: Pine grosbeak, redpoll, spruce grouse, ptarmigan, three-toed woodpecker, jay, and chickadee. The

[1] Mendenhall, W. C., op. cit., p. 57.
[2] Grinnell, Joseph, Gold hunting in Alaska, pp. 58-60.

same writer states that the first bird from the south arrived in 1899 on April 22. After that date many familiar birds, such as sparrows, thrushes, sandpipers, robins, loons, and blackbirds, came to the region for the summer.

SETTLEMENTS AND POPULATION.

In 1910 there were only about a dozen white people in the entire Shungnak region, though in 1898, when a rush to the Kobuk was in progress, there were several hundred. The only village at the present time is Shungnak, where the United States commissioner and recorder for the district formerly lived and where a post office is maintained during the six winter months. A Friends mission has also located there. The town is the headquarters of the Government schoolteacher and superintendent of the reindeer herd. There is a small store kept by a trader, but usually not many supplies are kept in stock, so that by the end of the winter they are practically exhausted. Around this white settlement a group of native camps has grown up and before the fishing season commences over a hundred natives are settled within a short distance of the white men's cabins.

Three or four prospectors are now living on Dahl Creek and Shungnak River. On the former stream four or five cabins, several of which are now deserted, are located near the southern face of the Cosmos Hills, and on Shungnak River is a similarly located cabin. On Dahl Creek, 2 miles or so above the lower cabins, are prospectors' camps. These are the only inhabited white men's cabins in the region, but there are many others now deserted along both the Kobuk and its tributaries. Some of these deserted cabins are located as follows: Near the head of Riley Creek, near the forks of Ruby Creek, on the slopes of the valley of the left fork of Ruby Creek, on Wesley Creek, near the lower end of the canyon, on the lower part of the Kogoluktuk, and at scattered intervals along the Kobuk, the largest number at any one place being near the mouth of the Ambler.

The largest settlement of natives is, as already noted, near Shungnak, but there are also smaller settlements along the Kobuk. The largest of these is probably the one called Kalla, near the mouth of Kollyoksok River. It is impossible to give any accurate estimate of the native population, for during the summer many are away on hunting or fishing trips or go down the river to Kotzebue. Mr. Robert Samms, the missionary on Kotzebue Sound, after a careful estimate during the winter of 1898, placed the number at 500. According to the governor's report for 1910,[1] the enrollment of children at the Shungnak school during 1909 was 61, and this of course represented only a small part of the native population of even the Shungnak region.

[1] Report of the governor of Alaska for 1909, Washington, 1910, p. 20.

Most of the travel in the region is by boats during the summer and by dog teams during the winter, so that good trails are more or less lacking. However, owing to the need of communication between the mining camps and Shungnak during all seasons of the year, the United States commissioner wisely had certain prisoners build a trail from the town to the upper placer diggings on Dahl Creek. Another trail has been built from the Kobuk, near the mouth of Wesley Creek, to the mine near the forks of Ruby Creek. A boiler was taken over this trail by dog team in the winter, so it has been well leveled and brushed out, but it is not very good for summer travel. Connecting with this is a well-marked trail from Dahl Creek to Wesley Creek along the southern slopes of the Cosmos Hills.

These are the only marked trails in the region, but horses may be taken through the hills or the lowlands back from the larger streams by one experienced in Alaska travel. The Survey outfit was carried by pack animals, and it was possible to go practically at will where the work required.[1]

DESCRIPTIVE AND HISTORICAL GEOLOGY.

GENERAL STATEMENT.

Only a small part of the Shungnak region has been seen in detail, so that the description of the geology is necessarily confined to the larger subdivisions, and no attempt has been made to map more than three main groups into which the rocks and surface deposits naturally fall. These are the metamorphic rocks, both sedimentary and igneous, the Mesozoic and Tertiary (?) rocks, and the unconsolidated sands, gravels, and glacial detritus. Such a classification serves not only to differentiate the rocks on lithologic and textural grounds, but it also places them in historical order, beginning with the earliest and closing with the latest deposits. Not only are the geologic features described, but the history of the region is traced as far as the structure and lithology give insight into past conditions.

METAMORPHIC ROCKS.

The oldest rocks in the region belong to the metamorphic complex. The greatest areas of this group are in the Cosmos Hills and the Baird Mountains. In these localities several hundred square miles are underlain by these rocks. In the highlands south of the Kobuk these rocks do not occur, but they are believed to extend for several score miles north of the mapped area, and east and west they probably continue uninterruptedly from Seward Peninsula through the headwaters of the Koyukuk to the Yukon. Rocks of different

[1] The efficient and competent manner in which the Survey horses were taken through the region was due to the untiring activity and skill of the head packer, A. G. Winegarden, of Montana, to whom the writers desire to publicly express their thanks.

composition, age, and modes of origin are grouped together in this metamorphic complex, which is termed a complex mainly because so little work has been done to determine its stratigraphy rather than because it is undeterminable. Both sedimentary and igneous rocks are represented in this group. Though the former occupy a greater area, it is impossible as yet to state the relative proportion of each.

The sedimentary rocks of metamorphic character are quartzose schists, crystalline limestones, and sheared conglomerates. The quartzose schists, as their name implies, are composed mainly of quartz and mica or chlorite. They can not be distinguished by the eye from many of the rocks of Seward Peninsula. The amount of shearing and attendant metamorphism has had an important effect upon the physical character of the rocks; thus in places they are schistose, with wavy or knotted cleavage, and secondary minerals such as mica have been but sparingly developed. In this group are the black graphitic quartzose slates so commonly found in the vicinity of the productive placers in Seward Peninsula. Slates and schists of this type are found near the lower placers on Dahl Creek where the stream leaves the Cosmos Hills and on the divide between that stream and Riley and Ruby creeks. Smaller areas are also found at other places and there seems to be a rather close connection between this rock and the placers. In most places there are a great number of quartz veins and lenses in the graphitic slates and schists, ranging from microscopic filaments to masses 2 or 3 feet in width and traceable for several hundred feet along the strike. Veins of this sort are particularly numerous on the divide between Dahl and Riley creeks, and the whole hillside from the divide to the latter stream is covered with a heavy quartz float, many of the pieces weighing a hundred pounds or more.

Bluish-white crystalline limestones are closely associated with the schists of sedimentary origin. They also have been deformed, and their irregular distribution clearly indicates that they have been subjected to pronounced dislocation. It is therefore not always possible to make out with certainty their relations to the other metamorphic rocks of the region. In the area between Wesley and Ruby creeks it is certain that the limestone overlies the black slates and schists, and the same relation is shown on the central part of Dahl Creek. There is, however, a possibility that the apparent relation may have been induced by faulting, so that the stratigraphic succession may not be as suggested.

No definite information as to the age of the limestones was obtained, as fossils have been in large measure destroyed by metamorphism. In the float in the central part of Dahl Creek, not far from an outcrop of a down-faulted block of limestone, indistinct corals were found in a limestone bowlder. These were too poorly preserved to permit specific determination but were of precisely the same appearance as fossils collected in 1909 from the limestones along the eastern flanks of the Darby Range in southeastern Seward Peninsula that were identified as Devonian and Carboniferous.[1] Another similarity between these limestones and some of those of Seward Peninsula was the strong petroliferous odor emitted when freshly broken. The limestones with these particular characteristics were dark, nearly black in color, with interlaminated bluish-white bands, the whole somewhat crystalline.

The schistose conglomerates that were observed in the region are especially developed in the southern part of the Cosmos Hills. In this locality the conglomerate occupies a strip about 2 miles wide trending in a general east-west direction and has a southward dip. Although the relations to the other metamorphic rocks are not perfectly clear, the direction of dip indicates that the conglomerates overlie the schists and slates. Further evidence in support of this interpretation is afforded by the fact that recognizable pebbles of black slate and of chloritic schist, together with numerous quartz pebbles, make up the conglomerate. These pebbles prove by their presence that schists and slates with quartz veins were in existence and had been eroded before the deposition of the conglomerate, and they suggest an unconformable relation between these rocks and the conglomerate. No pebbles of limestone were recognized, and the structure is not sufficiently definite to prove whether the limestones antedate the conglomerate or not.

On the succeeding page another conglomerate is noted, but it should be distinctly understood that the one described above and included in this section dealing with the metamorphic rocks is thoroughly sheared and schistose throughout its extent and can in no way be explained by the small amount of deformation to which the later-described conglomerate has been subjected. Not only have the pebbles composed of the softer rocks been deformed, but even the quartz pebbles have been pulled out and elongated, so that now they are many times their original length. Many pebbles 3 inches long were recognized, but this measurement, however, should not be interpreted as showing maximum distortions, for by excessive elongation the pebble form becomes more and more obliterated, so that finally it can not be recognized.

Igneous rocks that have been subjected to pronounced deformation and consequent metamorphism have also been recognized in the Shungnak region, but the exposures examined were poor. An outcrop of greenish schists belonging to this group extends for some distance along the ridge between Cosmos and Wesley creeks a mile or

[1] Smith, P. S., and Eakin, H. M., Geology of southeastern Seward Peninsula and the Nulato-Norton Bay region: Bull. U. S. Geol. Survey No. 449, 1911, p. 48.

so south of Iron Mountain. It appears to cut the underlying slate and forms a sill between that rock and the overlying limestone. So far as observed it does not cut the limestone nor does that rock show any contact effects. Metamorphism, however, has proceeded to such lengths that these criteria are not definitive. These older igneous rocks have a schistose structure, are greenish in color, and consist mainly of greenish chlorite and plagioclase feldspar, the latter as a rule completely recrystallized. They bear a close resemblance to the metamorphic greenstone schists of Seward Peninsula and are believed to have had a similar history and origin.

Taken as a whole, the metamorphic rocks show that two or possibly three periods of deposition have taken place. Two of these may have been separated by a period of metamorphism and erosion. Veins were injected prior to the deposition of the conglomerate and its subsequent metamorphism. Though it is by no means certain that there was an earlier period of metamorphism before the veins were formed, such a conclusion seems to be indicated. Igneous activity also occurred. Its extent has not been determined, but it does not seem to have been connected with the formation of valuable mineral deposits. The metamorphic rocks, with the exception of the conglomerates, seem to be mineralized and they are believed to be the ones in which deposits of metallic minerals are to be sought and from which the placers have been derived.

MESOZOIC AND TERTIARY (?) ROCKS.

A vast area south of the Kobuk, represented within the Shungnak region by the Sheklukshuk Hills, is occupied by sedimentary rocks assigned to the Cretaceous. As has already been stated, these hills have not been explored within the mapped area by members of the Survey, and as there is no description in the literature knowledge of them has been gained only by explorations east of the Shungnak region and by the long-range recognition of certain characteristics elsewhere studied in more detail. From these observations it appears that many of the higher points and a large part of the range consist of conglomerates with some sandstones, the relative proportion of the latter increasing toward the south. These beds have been folded and faulted, but in no place has schistosity of a marked character or of extensive development been seen. Emphasis is placed upon this feature because it is important in separating these newer rocks from the sheared conglomerates of the metamorphic complex.

The pebbles composing the lower part of this group have been derived from the older rocks and present a great diversity of lithology. Quartz derived from veins and lenses in the schists forms the larger number of fragments. This is probably due not so much to the abundance of the quartz in the schists as to its greater hardness, which prevented rapid destruction. A large part of the finer material found in similar rocks farther east seems to be of volcanic origin, and the rocks contain abundant plagioclase and ferromagnesian minerals.

These more recent rocks occupy a part of the northern lowland and occur on the flanks of the bordering hills. These rocks in the lower part of the Ambler basin are described as follows by Mendenhall:[1]

> Along the lower course of the Ambler outcrops were examined which consisted of a series of conglomerates, soft cross-bedded sandstones, and shales which were often carbonaceous and carried obscure remains of plant stems. Some phases of the conglomerate are made up wholly of material derived directly from the mica schists and but little sorted. White vein quartz, somewhat rounded, furnishes most of the material for the pebbles, which are embedded in a matrix consisting chiefly of fine muscovite and chlorite foils. These beds make up the low hills between the lower Redstone and the Ambler and between the latter stream and the Kowak [Kobuk]. Similar beds associated with limestone are reported by Mr. Prindle along the middle course of Shingurk Creek [Shungnak River].

Fossils have not been found in any of these rocks within the mapped area. Mendenhall,[2] however, on the basis of their lithology and similarity to fossiliferous beds on the lower part of the Kobuk, assigned the beds in the lower part of the Ambler to the Tertiary system. In the light of the further evidence afforded by the surveys of 1909 and 1910 in the region south of the Kobuk, whereby a great Cretaceous area was outlined, it has seemed probable that these beds belong to the Mesozoic rather than to the younger era. According to this interpretation, the metamorphosed sediments on the south side of the Kobuk are part of the uninterrupted Cretaceous area that extends southward to the region beyond the mouth of Kuskokwim River and from Seward Peninsula on the west to Melozitna River on the east. The sediments in the northern lowland are considered to mark an infolded or infaulted block as the region of greater mountain-building stresses, the Baird Mountains, is approached. If, on the other hand, the younger rocks in the northern lowland are Tertiary, they may mark local basins eroded in the metamorphic and Mesozoic rocks in which later sediments have been deposited. Further investigation is needed to determine these points, but the question of age has little or no bearing upon the mineral resources.

In the region to the east igneous rocks cutting the Mesozoic and Tertiary (?) sediments have been recognized. Owing to the slight study of the later rocks in the Shungnak region no igneous rocks in place have been recorded, although they undoubtedly exist. It is highly probable that some of the unmetamorphosed basic dikes found cutting the metamorphic rocks may have been intruded during Mesozoic and Tertiary (?) time, but their upper age limit could

[1] Mendenhall, W. C., Reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska: Prof. Paper U. S. Geol. Survey No. 10, 1902, p. 41.

[2] Idem, p. 42.

not be determined owing to the absence of late sedimentary beds of known age. The types of igneous rock to be expected from analogy with the more fully studied regions are basic volcanic rocks such as flows and tuffs, mainly of andesitic composition. Some granitic intrusions also have been recognized, but if the evidence afforded by the eastern part of Seward Peninsula is applicable here most of the granitic intrusions were pre-Cretaceous.

Veins are practically lacking in the Mesozoic and Tertiary (?) areas, and consequently mineral deposits requiring veins for the derivation of their valuable constituents should not be sought for in areas occupied exclusively by this group of rocks. The only economic resources likely to occur in these areas are coal beds, but, as will be shown in the section dealing with the economic geology of the region (p. 304), these resources are probably not sufficiently valuable to tempt expensive investigation.

UNCONSOLIDATED DEPOSITS.

Although the hard-rock geology is of prime importance, the placer miner is most intimately interested in the unconsolidated sands and gravels in which valuable mineral deposits may be sought. There are many different conditions under which the unconsolidated deposits were formed, and in order to understand these it is necessary to point out the recent history of the region, especially as regards the agencies. In order to do this the physiography of the region will be treated from the close of the latest period of mountain building down to the present.

TERTIARY AND RECENT HISTORY.

At the close of the last great mountain-building period, highlands trending in general east and west had been formed in the region between the Kobuk and Noatak. Probably the Mesozoic and Tertiary (?) sediments covered this range and metamorphic rocks were practically absent from the surface. Owing to the great elevation, erosion was more active in the high mountains than in the lower areas and consequently sooner removed the surficial covering. The drainage originally trended at right angles to the mountain range, and consequently the streams flowed north toward the ancient Noatak or south toward the Kobuk. The deformation, however, by no means resulted in a single anticline but was marked by several subordinate parallel ridges with intervening synclines or down-faulted areas. Each of these influenced the drainage and longitudinal valleys resulted. The northern lowland is interpreted as marking one of these constructional low areas where the Mesozoic and Tertiary (?) sediments had been relatively least elevated. The

Kobuk lowland probably marks another such area. After the drainage had been well established on this relief, valleys were eroded and the surface no longer corresponded to the constructional surface because the rivers were striving to cut their courses down and all the other processes of erosion were reducing the country to slopes appropriate to degradational processes. Thus, while the general position of the larger units of the region had been outlined by the mountain building, the present topography probably nowhere shows any vestiges of the actual surface that was produced by this process.

When the surface of the region had been carved to one somewhat remotely resembling that of the present, either a climatic or some other change capable of producing glaciation in the highland areas took place. In this period of glaciation and in the succeeding time which extends down to the present the unconsolidated deposits treated in this report were laid down. Although sands and gravels undoubtedly were deposited earlier than the period of glaciation, they have not been recognized in this region. In this report, therefore, two classes of deposits are described—first, those of glacial origin and, second, those formed after the period of glaciation, which for convenience are called stream gravels. This nomenclature is not entirely appropriate, for the glacial deposits were in many places transported by streams and have water-laid rather than ice-laid characters.

GLACIAL DEPOSITS.

During the period of maximum glaciation the ice centering in the highlands of the Baird Mountains on the north flowed down the existing valleys and covered the lowland areas. During the advance most of the former valley fillings of gravel were eroded and transported by the glaciers. The maximum extent of the glaciers has not been determined, owing to the lack not only of detailed studies but even of exploratory surveys over much of the region. Ice extended down the Kogoluktuk Valley, across the northern lowland, through the Cosmos Hills, and even into the Kobuk Valley. The Ambler Valley was also occupied by glaciers, at least as far as the Kobuk. Mendenhall [1] states:

> About 2 miles above the mouth of the Ambler River, on its left bank, occurs a deposit of blue bowlder clay 25 feet in thickness. Blocks and pebbles of dark crystalline limestone, much greenstone, and relatively small amounts of conglomerate and sandstone are scattered through the clay, and these bowlders are sometimes subangular and finely striated. The rocks of the lower course of the Ambler are sandstones and conglomerates, so that the greater part of the coarser material in the clay has been transported at least some miles. Overlying the clay are deposits about 100 feet in thickness of irregularly stratified yellow sands and clays without coarse material. The lower portion of this deposit at least is to be regarded as a true ground moraine, thus proving the extension of the Ambler Valley glacier to beyond this point.

[1] Mendenhall, W. C., op. cit., p. 48.

The proof of the extension of the Kogoluktuk Valley glacier, at least as far as the Kobuk lowland, is afforded by the distinct morainic topography of the knobs and kettles as far south as the lower cabin. No definite proof of the amount of ice in the Kobuk Valley has been obtained, but the effect on some of the streams indicates a body of ice of considerable extent. No frontal moraines of the glacier that occupied the Kobuk Valley have been recorded, although recessional moraines of the tributary streams are sharp and definite.

Attendant upon the advance of the ice was the blocking of preexisting drainage and the consequent discharge of water by unnatural channels. This continued through the period of maximum glaciation and even into the closing stages, so long as free discharge was prevented. Marking these obstructions are deposits of unconsolidated material laid down behind the ice barriers in temporary lakes or quiet water. Narrow gorges through the hills also attest the effect of past obstruction of the drainage. Except the passes of the larger streams, such as the Kogoluktuk and possibly the Shungnak, which were occupied by ice, the low passes through the Cosmos Hills were probably spillways for the impounded water that was not able to pass out by its normal course by way of the northern lowland, owing to the presence of the Ambler and the other glaciers.

Not only were deposits formed in those places where obstructions caused diversion of drainage, but even where a free discharge was permitted glacially eroded materials were deposited beyond the front of the ice. It is at present impossible to indicate just how extensive were the modifications of the topography produced by this enormous outwash of material. Without doubt much of the higher parts of the Kobuk and northern lowlands is formed of this group of deposits, though definite criteria are now unrecognizable, as the gravels have been partly transported by running water. The problems connected with the glacial occupation of the region are of importance in the search for productive placers as well as in deciphering the details which are of more purely scientific interest.

From the nature of the agency involved in gathering and transporting the materials that compose the glacial deposits, certain facts concerning the general character of these deposits may be inferred. First, owing to the lack of sorting action by glaciers during transportation deposits directly formed by glaciers generally consist of a heterogeneous collection of material unaffected by gravitative selection. Second, owing to the way a glacier acquires the materials it transports and its great erosive power, the deposits it makes are, as a whole, less weathered than those formed by rivers. The rocks are ground down or plucked bodily from the bed, so that a rock flour results from the erosion rather than a separation of the constituent rock minerals. Although the above statements apply only to deposits formed directly by glaciers, they require but slight modifications to fit the indirect deposits formed as outwash from the front of the ice. They are, therefore, important principles which will be referred to later in discussing the possible extension of the auriferous placers (p. 298).

STREAM GRAVELS.

With the disappearance of glaciation the drainage modifications that had become established were continued and the temporary features due only to the ice occupation were abandoned. As a result channels marking short-lived discharges, now unoccupied by streams, are represented by passes such as that between Wesley and Ruby creeks or by the divide at the head of Cosmos Creek. With the development of the new drainage the streams were in some places forced to excavate part of the glacial filling of their valleys; in other places glacial erosion had deepened the valleys so that stream deposition took place; in still other places glacial modification was so slight that the streams flow almost on the preglacial surfaces.

In those stream valleys where glacial deposits have been formed and subsequently in part excavated, bowlders derived from rocks outside of the local drainage basin in which they now occur are found in the gravels, together with fragments which have not traveled so far. In the excavation of the valleys by the present streams the changed relation of the drainage is such that in many places the stream has not stopped its downcutting after incising its course through the unconsolidated deposits but has cut down into bedrock, forming a narrow gorge. In these places the gravels are relatively thin and are derived largely from the local rocks, although the harder and larger blocks from the older, higher gravels may occasionally be found. The incision of the present streams in narrow rocky gorges may be seen in many places where previous glacial filling is not indicated. Thus the Dahl Creek valley seems not to have received any such additional material from outside sources. This valley has a rocky trench near its base, in which the stream flows, and an older, more open valley above.

The unconsolidated deposits formed by these streams therefore present a great diversity of types. In one type the materials have been derived from basins outside the one in which they now occur, but although they have been transported a long way the sorting has been but slight. In another type, although the material is not of local origin, the earlier deposits have been so thoroughly rehandled by streams that considerable sorting has been effected. In still another type the unconsolidated deposits consist only of materials that have been derived from the basin in which they occur and transported and deposited only by streams. Each of these different types can, therefore, in a measure be recognized by the size, shape, and lithology of its component materials. The recognition and the realization of the significance of the different characters presented by the different types of unconsolidated deposits are of importance to the placer miner, for certain types of deposits are more likely to contain profitable placers than others.

The physical condition of the stream gravels with respect to cementation by permanent frost has an important bearing on mining and prospecting, but the data available are not adequate for a thorough analysis of the problem. Practically all the shallow gravels are not permanently frozen. The thicker deposits, especially those in which there is a large amount of clay, and some of the bench gravels are probably frozen. In natural sections, such as occur along streams, definite evidence is not obtainable, for where the sun and air can reach the material thawing takes place. Thus a section of the gravels near the old cabin on the Kogoluktuk showed 4 feet of uncemented and unfrozen gravels overlain by 3 feet of frozen muck, which in turn was overlain by a cover of vegetation and frost litter. The upper frozen layer was so covered by the mat of vegetation which had been undermined by the river that it was protected from the sun and air, whereas the lower gravels were not.

The presence or absence of permanent frost seems to be in large measure determined by the effectiveness of subsurface drainage. Such drainage is best in well-rounded gravel deposits at an elevation above the streams and is poorest in those deposits containing a large percentage of clay or silt and lying below the level of the groundwater table. The fact that the mean annual temperature as determined from the mean of Stoney's observations (quoted on p. 277) is less than 16° F., or 16° below the freezing point, makes it possible to explain permanent frost in this region as due to existing climatic conditions.

ECONOMIC GEOLOGY.

HISTORY AND GENERAL STATEMENT.

The gold excitement which followed the Klondike discoveries caused a general influx of prospectors and others into all parts of Alaska. Every little while a new camp would be reported and a rush to the new diggings would be started. During 1898 such a stampede into the Kobuk occurred. Many of these gold seekers were unequipped for the difficulties encountered, and as they failed to find enormously rich placers they spent the winter loafing in their shacks and when reports of the rich strikes at Nome and on the Koyukuk reached them they struck out for the new fields. An account of the experiences of one of the disappointed gold seekers on the Kobuk[1]

[1] Grinnell, Joseph, Gold hunting in Alaska, Chicago, D. C. Cook Publishing Co., 1901.

gives a realistic picture of what was almost the universal condition in the region during 1898 and the early part of 1899.

With the opening of navigation in 1899 almost all the prospectors who could do so left the Kobuk and reported the region as worthless. A few prospectors have stayed with their claims and have each year taken out enough gold to live on and do a little more prospecting, buoyed up by the hope of a rich strike. It is probable that between $50,000 and $75,000 in gold has been produced since 1898. There is an enormous region to prospect, however, and with scanty means and small outfits progress has been slow. Attempts have been made, so far unsuccessfully, to interest outside men in financing different projects.

Not only have placers attracted the attention of the prospectors, but lodes of gold, copper, and silver-lead have been located and some development work done. No production has been made and there has not been enough exploitation to demonstrate satisfactorily the character or extent of the ore bodies.

The economic conditions imposed by the geographic position of the Shungnak region have exercised and must always exercise a control that will prevent working deposits which in a milder climate and in more accessible regions could be successfully mined. It is not possible to evaluate these factors, but a brief consideration of even the single item of wages may indicate the relatively high costs that must be met.

In the Shungnak region practically no white men are working for wages, so that there are no accurate data on this subject. From the fact, however, that ordinary pick and shovel miners demand $7.50 a day and board at the Squirrel River diggings, nearly 200 miles down the river, and consequently nearer civilization, there is small reason why miners in the Shungnak region should receive less. It is true that some of the placer miners pay natives $4 a day and board, but as a placer miner can work for only 60 to 80 days a year and must in that time gain sufficient to live for the other 275 days or so, $7.50 a day is by no means an excessive wage. The short season, of course, will be in part nullified if lode mines or deep placers are discovered which would give employment during the winter months. These, however, would probably not afford employment for all the miners required for open-season mining. Some decrease in living expenses is, of course, to be expected as transportation facilities are improved. As the country raises practically no foodstuffs and probably can not, it is necessary to import everything. The long distance that such supplies must be carried, the frequent handling required, and the short season available for water transportation make it improbable that any considerable reduction can be made in this item. Consequently, as these charges must be met by wages, the apparently high cost of labor must be regarded as an almost inevitable result of the isolated position of the region.

GOLD PLACERS.

From the foregoing statements concerning the number of miners in the Shungnak region, it is evident that placer mining is not carried on extensively and the production from the region is but little more than enough to pay wages to the few men employed. The main placer developments are on the streams heading in or flowing through the Cosmos Hills, namely, Dahl Creek, Shungnak River, and Riley Creek, a tributary of Kogoluktuk River. Each of these will in turn be described and the general placer resources of the region noted.

DAHL CREEK PLACERS.

Dahl Creek is a stream 7 to 8 miles long, the lower 3 miles or so of its course being through the Kobuk lowland, the middle 2 or 3 miles in a narrow rocky gorge, and the upper mile or two in a rather open valley. The placers that have been worked are located near the southern face of the Cosmos Hills and in the central part of the valley, where the junction of three small side streams with Dahl Creek has made a small flat. During the time that the Survey party was in the region no work was in progress on any of these claims, but mining had been carried on earlier in the season at both places and had been in progress for several years in the past.

The bedrock under the unconsolidated deposits here is black slate and schist with numerous small veins of quartz and in places some sulphide mineralization. The bedrock breaks into rectangular blocks of small size and the joint faces are often iron stained. The dominant strike is across the creek and thus the rocks make natural riffles for catching the gold. The slope of the bedrock surface is rather low, so that some difficulty is experienced in disposing of the tailings from mining. Near the lower group of claims schistose conglomerate outcrops but does not form bedrock under the productive placers. Limestone occurs near the placer ground in the middle part of Dahl Creek, but although float from this rock is found in the gravels it does not come down as far as the creek and does not form any of the surface on which gravel accumulation took place. Igneous rocks of a dense texture and greenish glassy color were noted upstream from the placers, but though these rocks have furnished many of the bowlders in the placer deposits they do not seem to have been connected with the mineralization and did not contribute valuable minerals to the placers.

Only the creek gravels have been mined on Dahl Creek. These average about 4 feet deep. In places they are only a foot or so thick but in others they are as much as 8 feet. Holes sunk on some of the low benches on either side of the stream have shown unconsolidated deposits 15 feet thick. Practically all the stream gravels are unfrozen, except for seasonal frost, but some of the low benches that have been prospected are reported to be permanently frozen.

The gravels in the productive placers are typical creek gravels, consisting of well-rounded pebbles with only a small amount of muck. Large, somewhat angular bowlders, most of which are of local derivation, are numerous in the gravels and cause a good deal of trouble in the mining operations. One of these large bowlders a short distance below the placers, near the southern face of the Cosmos Hills, measured 14 feet in length. It is made of the sheared conglomerate and has not been transported far. Many smaller bowlders occur directly in the auriferous gravels, however, and it is necessary to blast them out of the way.

The pay streaks differ in no essential respect from the overburden. They are usually from 1 to 2 feet in thickness and practically all the values lie in and on bedrock. The distribution of the auriferous gravels is very irregular, and it has been impossible to trace successfully any continuous pay streak. The values occur in pockets which when exhausted give no clue as to their relation to other rich spots. Such a distribution seems to indicate that values were either laid down more or less evenly and then dispersed by a change in the discharge of the creek, or else that the gold was originally deposited by a stream having strong variations in transporting ability.

Owing to the irregular distribution of the gold, statements of the value per cubic yard are of little significance. When a rich spot is found, several hundred dollars may be taken out in a few days, but at other times only a dollar or so a day can be made. Figures for the total production are also unsatisfactory, but they give a more accurate estimate of the value of the ground. The returns are not complete and probably exaggerate the amount of gold recovered, but they are an index of the size and present importance of the creek. According to the returns from the miners, in no year has Dahl Creek produced more than $10,000, and probably half this amount is nearer a correct estimate for the average production during the last six years. If this assumption is correct, not over $30,000 has been taken from this creek since its discovery.

Only a small amount of Dahl Creek gold was studied, so that a full description can not be given. The gold examined from the upstream group of placers was of a reddish to brass-yellow color. The pieces were small and some were distinctly spongy and had fairly sharp outlines, as if they had not been transported far from their place of origin. Some wire gold was also seen, but it was rare. Nuggets of considerable size have also been found in this part of Dahl Creek. One of these was seen which had a gold content worth about $65. It was a fairly well worn piece and had a considerable amount of greasy-looking milky quartz attached. Assays are reported to have shown gold value of about $16.20 an ounce.

Among the concentrates from the Dahl Creek placers magnetite is the most abundant mineral. There is also a small amount of chromite, some of the pieces being a foot or so in diameter. Garnets are almost entirely absent. The occurrence of native silver in the concentrates has been reported and pieces nearly an inch in diameter have been examined. The silver seems to be particularly free from admixture with other metallic minerals such as copper or lead; a small amount of cadmium, however, was recognized by blowpipe examination. No evidence was procured as to the bedrock source of the silver.

Mining is done by pick and shovel methods and the gold is won by passing the gravels through sluice boxes of whipsawed lumber. Owing to the high transportation charges, machinery would be expensive to install, and owing to the character of the gravels and their tenor, few mechanical devices could be successfully operated. Short ditches provide the necessary head for sluicing, and there is almost always a sufficient water supply to meet the demand.

From the physical features of the gold and the distribution and other characters of the auriferous alluvium, it seems probable that the gold has been derived from a source within the Dahl Creek basin, especially from the areas occupied by the black slates and schists. It is believed that the source of the mineralization is the quartz veins which are so abundant in this formation.

Some prospect holes have been sunk near Dahl Creek close to the southern front of the Cosmos Hills or the northern margin of the Kobuk lowland. The returns, however, have been insufficient to warrant development and the holes have been allowed to cave, so that it was impossible to examine a section of the gravels. It was reported by prospectors that the bedrock surface slopes southward at a high angle below the lower cabins, so that shafts even 40 feet deep failed to reach bedrock. In this lower part of Dahl Creek the stream is flowing through the unconsolidated deposits of the Kobuk lowland. The absence of any shallow placers in this part of its course seems to indicate that the upper parts of the gravels of the lowland area do not contain sufficient gold to form economic deposits where subjected to the sorting of such streams as Dahl Creek.

KOGOLUKTUK RIVER.

Sparsely disseminated colors of gold have been reported from many parts of the Kogoluktuk basin, but the only stream on which placers have been mined is Riley Creek. This is a tributary from the west, heading against the Dahl Creek divide and flowing first north and then east to join the Kogoluktuk. Placer ground has been mined in a desultory way by parties of one to three men on the headwaters of this stream since 1908. Mining was in progress here when the region was visited by members of the Survey in the early part of August, 1910, but soon afterward was abandoned for the season.

The placers occur in a region of black slates, limestones, and a few intrusive igneous rocks. The bedrock is similar to that of the placers on Dahl Creek except that limestones are much more numerous. Evidences of deformation and dislocation are pronounced and the stratigraphic succession of the rocks has not been determined. Quartz veins are particularly numerous in the black slates that form the bedrock under the ground that has been worked and are believed to be closely associated with the formation of the productive placers.

In the placers typical stream gravels are practically lacking. Sections show angular slide and slightly worn unconsolidated deposits of local origin in which are irregularly distributed bowlders from outside basins. Most of these foreign bowlders are of large size and are mainly igneous rocks belonging to the group of greenstones and associated rocks. They are generally well worn and probably have been brought into their present position by the combined action of ice and water during the closing stages of the glaciation of the northern lowland. Although these greenstone bowlders are found in the placers they are in no way connected with the origin of the gold, and their distribution, except as marking former glacio-fluviatile conditions, is of no economic significance.

The gold occurs mainly in the crevices of the bedrock and in the angular unconsolidated material lying on top of the bedrock. In the part of the deposit that is mined large bowlders are less numerous than in the upper 2 or 3 feet of the deposit, but there are many bowlders even in the pay streak. The whole character of the material in which the gold is found is more like that of residual placers than that of ordinary creek placers.

The slight amount of transportation that the auriferous material has undergone is also indicated by the shape and quality of the gold. Practically all the pieces examined were sharp and angular and many had small particles of quartz attached. No large nuggets have been reported from these claims. Pieces worth as much as 50 cents were seen, and a few worth \$2 to \$3 were reported. The gold is bright and in an average sample the pieces were worth from one-tenth cent to 2 cents each. The individual particles are spongy and consequently appear, to one not used to the run of placer gold, to be worth much more than is actually the case. The precise assay value of the gold was not learned, but it was understood to be about \$16.25 an ounce.

Accurate estimates as to the total production are not available, but from the amount of ground that has been mined during the last three years and its reported tenor it is believed that not much more than a thousand dollars a year in gold has been won.

Mining costs are high and the Riley Creek placers are unfavorably situated for economic development. The two greatest obstacles to cheap mining are the absence of a sufficient water supply and the presence of large bowlders. The latter trouble, however, is not so serious as the lack of water, for few of the bowlders are so large that they can not be rolled back by hand or got rid of by undermining. Practically the only water available is derived from the melting snow on the northward-facing slope of the divide between Dahl and Riley creeks. Furrows parallel with the contour have been dug on the hill slope to collect the surface and shallow seepage water formed from the melting snow banks. From these furrows the water is led down the hillside and impounded behind a sod dam. Thence it is led by a short ditch and hydraulic hose to the sluice boxes. So slow is the collection of water that under favorable conditions it takes about 3½ hours to collect enough for 1½ hours' sluicing. No water, of course, can be spared for groundsluicing. Even shoveling into the sluice boxes can only be done for four or five periods a day. During wet weather the reservoir fills up more rapidly and so relatively longer periods of sluicing are possible.

After the period of sluicing and while the reservoir is refilling the miners clean away the large bowlders and get everything in readiness for the next time that the water has accumulated. The large bowlders are not cleaned but are simply rolled upon the part of the claim already worked out. In order to use the water effectively the sluice boxes are made only about half the ordinary width and were formerly set on a pitch of 1 inch in 12 inches. Subsequently, however, in order to take care of the tailings and lessen the height to which the gravels were shoveled, a pitch of 1 to 15 was adopted.

The Riley Creek placers that have been worked seem to derive their gold content from the rocks exposed in the immediate vicinity. They are so situated that they have no adequate water supply and bowlders are so numerous that the placer can be developed only at great expense. Farther downstream, where the water supply might more nearly meet the demands, thicker overlying deposits and large bowlders are probably present. The absence of especially effective sorting in this part of the basin suggests that placers will be of distinctly local importance. The whole Kogoluktuk basin, so far as indicated by the conditions on Riley Creek, seems to promise only localized placers of irregular distribution, workable as pockets rather than as extensive deposits.

SHUNGNAK RIVER.

Placer mining on Shungnak River has been carried on for a mile or so below the narrow canyon in which this stream traverses the Cosmos Hills. Work has been in progress here during the open season almost uninterruptedly since 1898. Only two or three parties of three or four men each have attempted mining during any one year, and in 1910 only one placer camp of one white man and two or three natives was in operation. The use of native labor is an interesting experiment, and although it is reported that white men can do more work the wages paid the natives (about $4 a day and board) are so much lower that the difference in efficiency is compensated for.

Bedrock in the productive part of the river is mainly black slate and schist, but other sedimentary and igneous rocks occur at no considerable distance from the placers. Limestones occur near the head or northern end of the canyon but are not closely associated with the deposits of auriferous alluvium. The igneous rocks in proximity to the placer mines are composed mainly of serpentine, are of a dark-green color, and contain scattered particles of magnetite. These rocks have been sometimes mistaken for jade, and it is probably owing to this error that the whites have reported the name Shungnak to mean jade in the native language.

Most of the mining has been done near the southern face of the Cosmos Hills, where small flats permit turning the stream aside by wing dams. The gravels mined are generally shallow. The upper 2 feet or so is stripped off and the lower part only is put through the sluice boxes. The overburden is made up of typical river gravels with some large bowlders irregularly distributed throughout. It is not known whether the valley of Shungnak River through the Cosmos Hills was at one time occupied by ice, but it is certain that glacially eroded and transported bowlders have been brought in by glacio-fluviatile action and form part of the reworked material of the unconsolidated deposits.

The auriferous gravels are rather irregularly distributed and therefore mining has been in the nature of pocket hunting in those places where the water could be handled. The gravels are unfrozen, and in a measure this is a disadvantage, as it allows much water to seep into the pits. During high water the miners are sometimes driven out of the workings. The values are found in the lower part of the unconsolidated deposits and in the crevices of the bedrock, especially where the bedrock is black slate.

The larger part of the gold found in the placers of the Shungnak is in small pieces worth from one-half cent to 3 cents, but nuggets worth about $40 have been found, although they are by no means numerous. The gold is of a reddish color, and although not rusty it is not bright and shiny but has a dead luster. Its assay value is reported to be $16.70 an ounce. The form of the gold is very characteristic and is distinct from that of the gold from any other part of the Shungnak region, the little pieces being like shot flattened with a hammer.

Among the concentrates collected with the gold magnetite is by far the most abundant mineral. This is probably derived from the basic intrusive dikes which cut the metamorphic rocks. Garnet, or so-called ruby, is almost entirely absent from the gravels. Small nuggets of copper and also of silver are sometimes found in the sluice boxes. Some of the silver nuggets are nearly an inch in diameter and contain but very small amounts of other metals as impurities. No clue as to the origin of the silver was obtained, but the copper nuggets were probably derived from the zone of rock impregnated with copper sulphide near the limestone-schist contact, an example of which is described in more detail on pages 300–302.

Statistics of the production from the Shungnak River placers have not been kept, and estimates prepared by interested parties are not reliable. It is improbable that the annual production amounts to more than a few thousand dollars in gold, and a liberal figure for the total production from this river would not be more than $50,000.

SUMMARY.

The amount of development and the estimated production indicate that the gold placers discovered are not extensive or highly profitable. The gold seems in general to be of local origin and this necessarily curtails the area in which productive placers may be sought to the Cosmos Hills and the Baird Mountains. The general effect of the glaciation of the region has been to disperse auriferous deposits that might previously have been formed and so destroy rather than produce commercially valuable placers. Where glacial and attendant glacio-fluviatile action did not entirely remove the auriferous deposits it undoubtedly partly eroded and transported them, and this fact probably accounts for a good deal of the irregularity of distribution. The disadvantageous economic situation due to geographic and trade conditions does not need to be discussed at length here, but these conditions are necessarily deterrent factors in the development of these placers.

LODE DEPOSITS OF METALLIC MINERALS.

At the present time no lodes have been developed to a producing stage in the region and there are very few places where even prospecting has amounted to much more than the annual assessment work stipulated by law. As is usual, much of the trouble has been due to the prospectors overburdening themselves with more claims than they could handle, so that their efforts have not been concentrated on any particular place. Consequently, so far as affording information about the lodes is concerned the prospecting has been largely valueless, and one examining the region is forced to rely mainly on natural exposures of the possible lode deposits. There are indications of mineralization at many places, but the general inaccessibility of the region and the high valuation set on many of the prospects do not invite the investment of outside capital. Without abundant funds the developments are hampered and many of those attempted are ill directed.

GOLD LODES.

On the divide between Dahl and Riley creeks, as has already been noted, there are numerous veins in the black slates and schists. Most of these veins are small stringers, but some lenses 18 inches to 2 feet in width were noted. In one vein in particular on this divide specks of gold are reported in the quartz and a shallow prospect hole had been dug. The broken quartz from this hole had been panned and numerous small particles of gold are said to have been obtained. On the northern slopes of this ridge and continuing as far as the placers on Riley Creek there is heavy quartz float all over the surface. In many pieces of the float fine gold is visible and some containing several dollars' worth of gold are reported to have been found. The auriferous quartz from this place is mostly of a dense texture and a greasy white color. Sulphides are almost entirely absent. In this respect the veins resemble those of Seward Peninsula. In places the quartz is iron stained, but the discoloration is not present everywhere or in considerable amounts. The quartz in places shows indications of a comb structure and does not seem to have been recrystallized or badly smashed. On account of these characters it is believed that the veins from which this quartz was derived belong to a series formed later than the maximum period of regional metamorphism. This interpretation is further supported by the greater continuity of these veins as compared with those in the oldest schists of Seward Peninsula. It is believed that these quartz veins are intimately connected with the local placers on Riley Creek and that they are the sources from which the placer gold was derived.

An attempt to interest outside people in developing this gold quartz has so far proved unsuccessful. From the character of the exposures of quartz veins in the immediate vicinity it appears that the treatment of the vein material would require the handling and milling of a large amount of the country rock as well, and this would necessarily reduce the gold tenor. The question whether these veins can be worked is answerable only by careful and extensive sampling of the kind of material that must be mined and milled if the project is developed commercially. It is evident that picked specimens are absolutely worthless in arriving at the valuation, and samples of the vein material alone are likewise misleading.

There are many other places where veins similar to those at the head of Dahl Creek have been seen, and it is by no means improbable that they, too, carry some free gold, although in the hurried examination it escaped detection. These veins are more numerous in the areas occupied by the black slates, especially near the base of the limestones. This distribution appears to be dependent upon the physical features of the slates, but the deposition of gold may have been due to chemical reactions induced by the presence of carbonaceous material throughout these rocks.

COPPER PROSPECTS.

At two places attempts have been made to prospect copper leads, but at neither place have the explorations been sufficient to determine the extent or other geologic relations of the ore. One of these projects is located on the west side of Ruby Creek about 6 miles from the junction of that stream with Shungnak River. The other lies west of the left fork of Ruby Creek, near the head of Cosmos Creek. A low limestone hill, locally known as Aurora Mountain, is the center around which the claims at the latter locality are grouped, and this name will therefore be used to designate that locality.

Copper-bearing leads on Ruby Creek have been known for many years and were critically examined in 1906 by experts in private employ to determine their commercial value. Conditions at that time prevented the purchase of the properties, and only a small amount of work has been done recently. Owing to the length of time that has elapsed since active work was in progress, many of the pits and open cuts have caved and filled to such an extent that they afford poor opportunity for examining the deposits and adjacent rocks. In this part of the Ruby Creek valley on the lower slopes there is a heavy covering of talus and vegetation, so that without pits and other sections many important facts are indeterminable.

Mineralization on Ruby Creek appears to be confined to a brecciated zone or zones in the limestones. Sulphides have been deposited in the open spaces thus formed and the ore-bearing solutions have penetrated the limestone along the many cracks and crevices and in part replaced it. There is some brecciated dolomite at the mine, and it also has been replaced and intersected by sulphides. The sulphides of economic importance are mainly bornite and chalcopyrite, but galena and iron pyrite were also noted. In the surficial part of the deposit both the blue and the green copper carbonates are common. Limonite, derived from the weathering of the pyrite, in several places forms a gossan, or "iron hat," several feet thick over the sulphide-impregnated limestone. It is reported that the weathered material when panned yields colors of gold. Average pans of the gossan from an open cut above the main workings are said to give from 1 to 3 cents in gold. Assays are said to have yielded as much as 11 per cent of copper, but no details were obtained as to the manner in which the samples were taken.

The main developments on the northernmost property consist of an adit and two open cuts. The mouth of the adit is only a few feet above the high-water level of the creek. The tunnel has been driven about 40 feet through a much slickensided and fractured limestone, in places showing mineralization. Two short drifts, totaling only about 30 feet in length, followed especially strong indications of mineralization but evidently soon passed out of rich ore. The walls stand fairly well, but caving of the surface has so blocked the mouth of the adit that there is 12 to 18 inches of water standing on the track. A boiler was brought in from the Kobuk by way of the low pass at the head of Wesley Creek by a team of 70 dogs. When work was started a homemade mine car was used to tram the broken rock away from the working face, but a new automatic dumping car has since been installed. Wooden rails are, however, still in use. Natives have been employed as muckers and for the simpler mining operations and are said to have given satisfaction.

On the hill at an elevation of about 150 feet above the adit an open cut about 30 feet long and 10 feet or so wide had stripped the surface and had cut into the bedrock to a depth of 5 to 7 feet. Most of this pit was covered with caved surficial material so that little could be seen. The mineralization seemed to be essentially the same as that exposed in the adit. In the open cut although the bedrock is limestone it differs in some respects from that exposed in the tunnel, for none of the dolomitic phase was recognized and in places it seemed to be darker and suggested correlation with a higher horizon. However, there has been so much dislocation that the structure was not determinable and in the absence of fossils the above suggestion is to be regarded as little better than a guess.

At about the same elevation above Ruby Creek as the adit already described and 200 to 300 yards southeast of the open cut on the hill another open cut about 30 feet long has uncovered a zone of mineralization. The mode of occurrence is essentially the same as at the two other places, but only the upper weathered portion has been exposed. Copper minerals are less abundant here, but there is more limonite. Sulphides were but sparingly seen; the iron occurred mainly as oxide and the copper mainly as carbonate. It is reported that samples of the ore from this cut have a higher accessory gold content than that from either of the two other places.

About 3 miles west of the Ruby Creek copper leads is Aurora Mountain. The geologic structure at this place is essentially synclinal; brecciated and deformed limestone forming the top of the hill lies above a series of dark slates and schists that form the lower slopes. Near the contact between the two rock groups but occurring almost invariably within the limestone are indications of sulphide mineralization. The surface of the hill is so covered with frost-riven talus of limestone that except in artificial cuts the rocks are not exposed in place. Here and there copper carbonate float is found in considerable abundance.

Developments on Aurora Mountain consist mainly in finding places where the copper float is particularly abundant and then digging a hole through the overlying mantle of detritus. The only prospecting of this sort that has been carried to any considerable extent is on the northeastern slope of the hill about 300 feet above the contact of the limestone and schists. Exploration at this place at first consisted in sinking a shaft on the uphill side of a particularly conspicuous area of carbonate float. At the time this place was visited in 1910 the shaft was partly filled with water and its walls were so covered with ice that they could not be examined. It was reported that the shaft was about 22 feet deep and intersected a fairly promising copper lead about midway between the surface and the bottom. The bottom of the shaft is also said to have shown some good ore. Samples from the lower part of the shaft show bornite and chalcopyrite as well as carbonates.

Owing to the difficulty of mining the shaft was abandoned and a crosscut at about 250 feet lower elevation was commenced to connect with the deepened shaft. This adit is now in about 30 feet, and it will be necessary to extend it over 250 feet to reach a point directly underneath the shaft. Throughout its length the adit is in barren brecciated limestone, in few places showing any mineralization. Slickensiding is evident at many places, but although the amount of throw was not determined it probably was not very great, as different rocks were not brought into juxtaposition. In spite of the brecciation and faulting the rock stands well, and it has been necessary to timber only the entrance to the adit where it passes through the surface detritus.

Analyses by Thomas Price & Co.[1] of picked specimens of the bornite are reported to show 0.04 ounce of gold per ton, worth about 82 cents, and 1.4 ounces of silver per ton, worth about 91 cents, in addition to the copper content. Assays by the same analysts of chalcopyrite from Aurora Mountain yielded 0.01 ounce of gold per ton, worth about 20 cents, and a trace of silver in addition to the copper. Neither at Ruby Creek nor at Aurora Mountain, however, does the sulphide mineralization seem to have produced auriferous placers. In Ruby Creek colors of gold have been found, but at Aurora Mountain no placer gold has been reported in the stream gravels.

Although the Ruby Creek and Aurora Mountain localities are the only ones where prospecting has been carried on, there is probably similar mineralization at many other places. In fact, mineralization near the contact of certain of the limestones and schists has been recognized all the way from Seward Peninsula to this region. So far prospecting has failed to show that any of these deposits either in Seward Peninsula or in the Kobuk region are workable.

[1] Lloyd, L., unpublished letter.

Until the mode of origin and the general characters of ore bodies of this type are fully understood it seems unwise to do much dead work, such as running long crosscuts to intersect a possible ore body in depth. Even after a considerable body of ore has been disclosed a careful scrutiny of the costs of mining in this remote and rather inaccessible region should be made before expensive permanent mining machinery is installed. Although these facts should not discourage intelligent prospecting, they should serve as a warning that the search is likely to be expensive, as the cost of preliminary investigation will be high.

OTHER METALLIC RESOURCES.

Galena has been found in small quantities associated with the copper sulphides at both Ruby Creek and Aurora Mountain. A small amount of vein quartz and some brecciated and recrystallized dolomite with galena was seen near the high hill west of Wesley Creek. A shallow prospect hole has been sunk on this stringer, but so far the indications are not at all promising.

At many places magnetite in masses as much as a hundred pounds or so in weight has been found on the surface, especially near the limestone-schist contacts. Float of this sort is particularly abundant on the slopes of the sharp conical hill locally known as Iron Mountain, east of the pass between Cosmos Creek and the left fork of Ruby Creek. Specimens from this place show a nearly pure magnetite with here and there drusy cavities lined with small octahedral crystals of this mineral. As the magnetite has not been seen in place, speculation as to its origin is hardly warranted. There are no near-by igneous rocks, so it seems improbable that these bodies are due to contact-metamorphic effects. Owing to the occurrence of limonite and hematite bodies in similar limestones in the Solomon region of Seward Peninsula a tentative suggestion is that the magnetite of the Shungnak region may have been formed by the metamorphism of similar iron oxides which were laid down either contemporaneously with the inclosing limestones or earlier than the great period of dynamic metamorphism. The magnetite shows no signs of having been sheared, so it must have been either entirely recrystallized or deposited subsequent to the period of regional deformation.

Whatever theory of origin of these ores proves to be the true explanation probably matters little, for the deposits so far as known have but slight economic value. The high operating costs coupled with the absence of large ore bodies will necessarily deter capital from undertaking their development.

DEPOSITS OF NONMETALLIC MINERALS.

The geographic isolation of the Shungnak region has prevented and will probably for a long time prevent the development of any of the nonmetallic resources except such as can be consumed near the place where they are produced. Of these resources the water supply is the one most necessary for local uses, but so far it has been little developed. If mining of gold and other metallic minerals increases in the region, this source of power may become of great value. At the present time, however, placer mining is conducted on so small a scale that either a sufficient water supply can be secured by short ditches or the claims can not afford to pay for an adequate supply.

In the Mesozoic and Tertiary (?) areas of the Shekluksbuk Hills and of the northern lowland some coal has been reported. The chances of finding deposits of sufficient value to be used at places more than a short distance from the veins seem to be poor. This opinion is based on the fact that on the Kobuk a coal bed belonging in this same series of rocks, exposed on the banks of the river and situated almost 200 miles nearer ocean transportation, has not proved commercially valuable, although attempts to mine it have been made at intervals ever since 1886. Although probably none of the coals that may be found in the Shungnak region will support extensive industry, their value for local consumption may be sufficient to warrant the search for coal in the areas of Mesozoic and Tertiary(?) rocks near productive metal mines.

Some attempts have been made to mine asbestos. This mineral is found in more or less close association with the greenstone intrusives. Several holes have been made in ledges of this rock on the east side of Dahl Creek above the upper placer mines, and samples of the asbestos have been submitted to manufacturers. It is reported, however, that the asbestos although of good color has slight tenacity, so it is not suitable for making high-grade articles and therefore commands a low price. For ordinary purposes this asbestos is well suited, but the small amount paid for this grade is not sufficient to pay the transportation charges. Furthermore, the amount so far known is small, and it would therefore be expensive to mine.

In almost all the streams of the Shungnak region north of the Kobuk bowlders of a hard green, slightly translucent rock are plentiful. These are commonly called jade, but this determination is probably incorrect. A complete examination has not been made, but some pieces are undoubtedly serpentine, others are green quartzite, and still others are probably nephrite. The last-named mineral is closely akin to jadeite but is an amphibole instead of a pyroxene and is not of gem quality. It is doubtful whether any jade of value occurs in this region, for of all the material from the Kobuk so far examined by the experts at the National Museum none was jade. Even in the so-called jade no pieces of gem quality were seen. The imperfections are due to rock cleavage and to the presence of a metallic iron mineral, probably magnetite. The cleavage causes the mineral to split into thin layers, which makes cutting difficult and the surface flake off; the magnetite spoils the translucency and gives the stone a spotted appearance.

SUMMARY.

In concluding this report on the economic geology of the Shungnak region certain generalizations already expressed or implied seem of sufficient importance to bear repetition. At the present time the developments are on a small scale and their production is almost negligible. Prospecting has been inadequate to test the region thoroughly, but it has been commensurate with the number of men and capital available. The future of the region seems to depend more upon the auriferous deposits than upon the nonmetallic resources or the lodes of the base metals. Therefore unless placers of a type different from those now worked are found in the gravels of the lowland areas there is only a small field for prospecting and this is limited mainly to the Cosmos Hills. The geographic conditions affecting the economic future of the Shungnak region will continue to impose limitations that only especially rich deposits will be able to overcome. For these reasons, although a small and perhaps increasing production may be expected, the region as a whole does not seem to hold forth any great promise of large enterprises. It should be stated, however, that although the region may not rival the better-known camps it appears from the observations made in 1910 to have resources capable of supporting a small community, so that some prospectors and miners will find a profitable field for exploration.

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THE SQUIRREL RIVER PLACERS.

By Philip S. Smith.

INTRODUCTION.

During the later part of the open season of 1909 a new field of productive gold placers was discovered in the Kobuk mining district, Alaska. Although this camp is still in the early stages of development and although the production so far has been small, the promise held out to miners in this little-exploited field is attracting attention. The following observations were made in August, 1910, during a few days' visit to the new camp and are necessarily incomplete.

ROUTES AND ACCESSIBILITY OF REGION.

The productive area so far discovered is in the lower part of the Squirrel River basin.

The general position of this region with respect to better-known parts of northwestern Alaska is shown by figure 19 (p. 272). A larger-scale map of the eastern part of this field forms Plate XIII. This map is based mainly on surveys by Reaburn in 1901[1] and reports by prospectors, most notably John Tyapay, one of the original locators of Klery Creek, together with such notes as were collected during the writer's recent visit. But small cartographic precision can be claimed for this map, though the representation of the relation of the streams to one another is approximately correct. In such an undescribed region even a sketch map of this sort may be of service to the prospector and will certainly make the local nomenclature used in this paper much more easily understood.

Squirrel River is tributary to the Kobuk from the north, about 42 miles in an air line from Hotham Inlet or 60 miles from the nearest coast settlement, Kotzebue. Owing, however, to the circuitous course of the Kobuk and the approach to its mouth the distance to be traveled is 28 miles from Kotzebue to the mouth of the Kobuk and 68 miles from this point to Squirrel River, or a total of nearly 100 miles from Kotzebue. In the winter, when the region is ice-

[1] Mendenhall, W. C., Reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska: Prof. Paper U. S. Geol. Survey No. 10, 1902.

bound, access is much easier than during the summer, when countless sloughs and "niggerhead" tundra preclude overland travel.

Kotzebue is the seaport of the entire Kobuk region and is normally the home of a missionary and family, three white traders, a few boatmen and mechanics, and a small settlement of natives. After the break-up in the spring, however, missionaries, school-teachers, and prospectors, together with a great number of natives from all the neighboring rivers, congregate for trading and fishing in preparation for the coming winter, so that during July and August there are 600 to 700 people living in the town, which then stretches for more than 3 miles along the coast. A mail-boat service from Nome to this place is maintained every 10 days during the summer. The boats, however, are only 30 to 50 ton schooners with auxiliary gasoline power, and the passenger accommodations are cramped and inadequate, although the food is good. The trip from Nome by one of these boats takes about three days, as stops are made at many way points, and the charges in 1910 were $25 apiece for passengers and about $20 a ton for freight. It is not possible to use boats drawing more than 5 to 6 feet of water, as the channel up to Kotzebue is narrow, crooked, and shallow. Some larger boats from Seattle enter Kotzebue Sound, but they can not approach nearer than Cape Blossom, which is 10 to 12 miles south of the town of Kotzebue. In the winter a mail service by dog sledge once a month is maintained from Nome overland to Candle and Kiwalik and thence along the coast and on the sea ice to Kotzebue.

In the summer freight and passengers from Kotzebue for the Squirrel River diggings are transshipped to small gasoline launches or scows which draw only 2 feet of water or less and after crossing Hotham Inlet go up the Kobuk as far as the junction of Kobuk and Squirrel rivers. This trip takes from one to two days, depending on the stage of water and the load, and the charges are $15 apiece for passengers and about $15 a ton for freight. A short distance above the junction of the two streams is a small settlement formerly called Squirrel City but subsequently renamed Kiana. Here are a score or so of log cabins, a store and restaurant, and many native families engaged in fishing. It was understood that before the freeze-up two more stores were to be opened at Kiana and the recording office for the Noatak-Kobuk precinct was to be established at this place. The houses cling to the steeply incised valley walls, and there is but little drained flat land available on which the town can develop. Timber is scanty in the immediate neighborhood but can be floated down the Kobuk from points farther upstream where it is more abundant. Logs suitable for cabins were sold for a dollar apiece delivered in the water alongside the town. Water for domestic use is taken from Squirrel River and is likely to be contaminated unless care is exercised, but no other supply is available. Prices for staple articles in 1910 were high in Kiana owing to the cost of getting supplies into the region, the loss attendant upon the many rehandlings, and the lack of active competition.

To continue the journey to the placer diggings the next stage is by small boat from Kiana up Squirrel River. The country between the river and the hills is wet and swampy, and though during high water light-draft launches can go for many miles above the settlement, ordinarily the trip can be best made by dory or other boat drawing not over 6 or 8 inches of water. By this method Squirrel River is ascended for about 7 miles to a slough which makes off toward the north and east and which at the time of the visit by the Survey geologist was so shallow near its junction with Squirrel River that the dory, containing only about 500 pounds of freight, had to be partly unloaded and hauled over the shallow riffles by men lifting on each side of the boat. Finally the slough enters a nearly round lake between one-fourth and one-half mile in diameter, which is the nearest point by water to the placer diggings. The freight charges from Kiana to this place are 2 cents a pound. Several tents had been put up on the shores of the lake by some of the miners for their own accommodations, so that a traveler could obtain shelter. From the lake it is about 7 miles over rolling slopes to the placers that are being worked, but midway there is a road house where board and lodging can be had at a dollar a meal or bed. A freighter with two horses, employed mainly by one of the mining companies, makes more or less regular trips from the lake to the diggings. The trail is over very soft ground, where even the foot traveler is most of the time half-leg deep in muck and water, but the freighter is able to carry loads of 700 to 1,000 pounds in a two-horse wagon at a rate of about a cent a mile a pound. Although horses and wagons are used on this trail, one inexperienced in the country should be warned that only a thoroughly competent driver with horses long accustomed to the peculiar and treacherous footing can successfully make the trip. Furthermore, the cost of keeping horses in the region is great, for they must be fed oats, which cost from $100 to $150 a ton.

CLIMATE.

In addition to the difficulty of reaching the region in the summer time and the high cost of transportation, the shortness of the open season exercises a marked influence on the economic problems. The entire basin of Squirrel River lies north of the Arctic Circle, so that freezing weather prevails during much of the year. According to reports the ice is seldom out of Kotzebue Sound so that Kotzebue can be reached before the middle of July, and by the middle of September the rivers are frozen; it is unsafe to count on a much later season, though there have been years when the sound near Kotzebue was not closed before October. Therefore the open season is practically limited to two months, or about 60 days. Even during this period, however, snow and ice form. During 1910 on the night of August 15–16 ice formed on the sides of the streams and on the stagnant pools at an elevation of not more than 200 to 300 feet above the sea. On August 18 the hills around Squirrel River basin were covered with snow far down their slopes, though their tops do not reach elevations of more than 2,000 to 3,000 feet.

DRAINAGE AND RELIEF.

Little is known about the geography and geology of the Squirrel River basin. The main river probably heads against the Noatak basin on the north and the drainage into Hotham Inlet on the south. Broad flood plains traversed by sloughs and marshes occupy the lowlands from 1 to 3 miles wide on each side of the river and appear to be due mainly to the filling of a more deeply eroded older valley by thick deposits of gravel. Beyond the bottom lands the valley walls slope more or less abruptly to merge with the uplands. Even on the valley slopes, however, there are thick deposits of gravel which extend to elevations of several hundred feet above the normal level of Squirrel River. These deposits are recognizable not only in the Squirrel River basin but also for considerable distances along the Kobuk both eastward and westward.

The larger tributaries to Squirrel River, some of which are 30 to 40 miles long, in their headward portions flow on steep gradients over exposures of bedrock slightly covered with recent creek gravels. Farther down, however, benches, in part rock-cut and in part built of gravels, mark former stream levels below which the present tributaries are incised. In this portion the streams flow in rock-walled canyons, some of which are a hundred feet or more deep. Still farther downstream the creeks debouch from the hilly country and traverse the lowlands of the main river. In this part of their courses the streams are slow and have tortuous meanders and abandoned earlier channels forming sloughs that make approach difficult; no bedrock is exposed and probably it is at a considerable depth below the surface.

Little of the upland of the region was examined, so that only a most general description can be given. Viewed from a distance, however, the sky line is more or less irregular, but in general the elevations of the summits are between 2,000 and 3,000 feet. The ridges as a rule show but small undissected areas, the elevation in the main being the result of the erosive activities on the two sides of the divides. Along the summits of the higher ridges pinnacles of fantastically weathered rocks make prominent landmarks and afford excellent exposures of country rock.

VEGETATION AND GAME.

Throughout the region the vegetation is typically subarctic and arctic. All the trees show more or less stunting and the number of species is relatively few. Near the larger streams spruce forms a narrow fringe of dark green a few hundred yards in width. Few of the trees are more than a foot in diameter at the base and they taper rapidly toward the top. A few birches grow on the well-drained gravel terraces along the Kobuk, but they are not abundant in the Squirrel River basin. The white and the black birch are used as timber; the prostrate birch, which is of much wider distribution, is too small to be used even for fuel. Willow and alder are found along the smaller streams and necessarily will be an important source of fuel on many of the more remote creeks where spruce is lacking. The larger part of the basin is devoid of trees of any kind and the only vegetation on all the near-by flats and the lower hill slopes is rank grass and moss. Although the grass in places is abundant, it grows so rapidly during the long summer day and is so full of water that it does not make good feed for horses. When touched with frost, the grass seems to lose the little nourishment it had when green and stock dependent upon it rapidly lose strength.

Undoubtedly in the more remote parts of the Squirrel River basin large game, such as bear and caribou, may be found, but in the parts near the placer diggings this is not the case, and there are few indications that there has been much game in the region in the recent past. Ptarmigan and water birds, however, are abundant, and may be approached sufficiently close to obtain a considerable number, but it is believed that they are not to be entirely depended upon for food. Fish are numerous in all the streams. Salmon by the hundreds are caught in dragnets in the Kobuk and lower Squirrel River, and grayling may be had in almost all the smaller streams. So abundant are the fish that they may be safely counted on for food. The grayling will usually take either fly or bait hooks, salmon eggs on the eye of a grayling making the best bait.

GENERAL GEOLOGY.

Geologically the region presents many of the same features that are seen in parts of Seward Peninsula to the southwest. The rocks of the region, so far as known, belong in the group of metamorphic schists and limestones referred in Seward Peninsula to the Nome group. No further light was obtained as to the age of these rocks, but little hesitation is felt in assigning them to the Paleozoic or earlier periods. Schists of a variety of different characters were seen in the vicinity of the productive placers. Practically all the schists contain large amounts of chlorite, but some are dominantly quartzose and others are calcareous.

METAMORPHIC ROCKS.

The quartz schists are of two main types; one is a rather fine grained slaty schist of dark, nearly black color, with some carbonaceous material which is, in part at least, graphite; the other type is free from carbon, and the rock in fresh specimens is greenish gray, with mica or chlorite as the principal mineral observed on the cleavage surface and quartz the principal mineral observed transverse to that direction. The carbonaceous phase is lithologically similar to the Hurrah slate of the Solomon and Casadepaga region and the Kuzitrin formation of central Seward Peninsula, especially south of the Bendeleben-Kigluiak Mountains and in the southern part of the Kougarok district.

The calcareous schists, as their name implies, have a high lime content and are more or less schistose. All phases between a slightly sheared limestone and a thoroughly recrystallized schist are represented in this field. In the more schistose varieties there is an abundance of chlorite and mica flakes which increase proportionately as the lime content decreases. A yellow weathering color is in general characteristic of these calcareous schists, and topographically they do not form as prominent ridges as the limestones or some of the more quartzose schists. Some of the calcareous schists undoubtedly represent old sediments deposited contemporaneously with the sandstones which form the quartzose schists, for they appear to be interbedded with them. Some, however, are the sheared equivalents of the limestones, and these may belong to younger horizons than the quartzose schists.

Slightly sheared and metamorphosed limestones, similar in lithologic character to the thick limestones found in the vicinity of all the productive Seward Peninsula placer deposits, are recognized in the Squirrel River basin. In this district, as in the region to the southwest, these rocks make bare white hills practically devoid of vegetation, forming notable landmarks for long distances. Although minerals and structures due to dynamic deformation are developed in places throughout these limestones, the amount of metamorphism does not seem to be as great as in the quartzose schists and some of the calcareous schists. For this reason it seems probable that an unconformity exists between the heavy limestones and the metamorphic schists. This fact has not been definitely proved but seems to be indicated not only by the different amounts of metamorphism but also by the areal distribution of the limestones. No fossils have been found in the limestones of this region, and the prospector should be urged to save any traces of organisms that may be found in the rocks, as they may give a clue to many important problems.

IGNEOUS ROCKS.

In addition to the sedimentary rocks described there are also some formed by igneous agencies. These rocks are mainly the greenstones and greenstone schists. Only a few exposures of these rocks were seen, but the close similarity of the other rocks to those of Seward Peninsula suggests that probably, with more extensive study of the region, these old igneous rocks will be found to be fairly numerous. All the greenstones are more or less sheared and metamorphosed and were therefore introduced in the period preceding the great deformation of the region. None of the granites noted in parts of Seward Peninsula have been observed in this region, and there does not seem to be much probability that these more recent rocks have been injected in the neighborhood of the productive placers.

ECONOMIC GEOLOGY.

COMMERCIAL CONDITIONS.

As has already been noted, the developments in the Squirrel River region have been small, and although gold prospects are said to have been found on eight or ten tributaries of Squirrel River mining was in progress on only one of the streams, namely, Klery Creek. It is difficult to believe that this is the only place where productive placers exist, for conditions analogous to those on Klery Creek are reported at several other places in this basin. With further prospecting undoubtedly other places may be found as rich as the known ground on Klery Creek. There is, however, a strong tendency of prospectors to hold ground on a proved creek and prospect the adjacent areas only when driven to it by the exhaustion of the known ground or the inability to secure claims on a certain creek. Furthermore, the field in which placers may be expected to occur covers a large area, which takes time and money to prospect, and as yet there are but few men in the region and most of these have not enough capital to undertake any extensive exploration. At the time the region was visited by the Survey geologist there were not over 50 men in the whole region and about a third of this number were employed on one claim. Capital had not taken hold of the region, and there were few opportunities to work for wages; consequently the camps were run on a partnership basis and few of the men were equipped with the necessary supplies to carry them for a year or so of unproductive labor in building drains, etc., preparatory to opening a property. Wages were said to be $7.50 a day and board for ordinary miners, but as there was only one company employing men and as that company was able to obtain all the help it needed at $5 a day the above figures are more or less fictitious. While the labor conditions will undoubtedly change if the camp proves successful, persons should be warned against going to Squirrel River if they have nothing but wages to depend on. In 1910 there was employment for only a few men, so that without supplies or funds the venture would be unsuccessful.

Furthermore, the usual wholesale staking of the region has tied up much of the available ground, so that unless the prospector goes to some distance from the productive creeks his chance of obtaining a claim by original location is slight. One is therefore compelled to go to a considerable distance from the proved ground or else buy or obtain a lay on a recorded claim. Any of these choices compels additional expense which the prospector should be prepared to meet. The unjustness of the system is well shown on Klery Creek, where 64 claims have been recorded above the Discovery claim and at least 20 below that point, and yet work has been done on only 10 of the claims and of these probably not more than four or five have produced a thousand dollars during the last year. This statement is not intended to discourage prospecting but only to point out the small amount of work really in progress.

PLACERS.

CREEK PLACERS.

As Klery Creek is the only stream on which mining is in progress and as two or three claims on this stream were seen in detail, a description of its placers will be given. It should be borne in mind that the general facts seen at the placers where mining is being done are to be expected in similar places throughout the field, and the facts learned by mining on one claim are helpful in the understanding of unprospected ground.

The most active work is in progress near the mouth of a small tributary, Jack Creek, a short distance above the Discovery claim. At this place there is a rock-cut gorge with a gravel-covered floor about 150 yards wide. On this floor the stream formerly followed the eastern side, but in order to allow mining the stream was turned to the other side by a roughly constructed dam. Owing to the exceptionally rainy season of 1910 the stream was abnormally high, and three times during the summer the dam was completely washed away by the floods and some of the sluice boxes with the gold in them were recovered only with difficulty. The upper 12 to 18 inches of gravel in the bed where the stream had been turned aside is removed by shoveling it aside and the larger bowlders are either rolled back upon worked-out ground or are pulled out of the way by a team of horses brought in the spring from the Inmachuk. This stripping is done rapidly and is carried down to a point where the gravels show some "sediment" or fine mud coating the pebbles and filling the interstices. None of this surface material is put through the sluice boxes, as repeated experiment has shown that it contains practically no gold. Between the upper foot or foot and a half of gravel that is stripped off and bedrock is 12 to 18 inches of gravel in which values are obtained. These gravels are typical river wash but have been less recently handled by the stream than the upper ones. The lower gravels, together with the upper 6 inches to a foot of disintegrated bedrock, are put through the sluice boxes and it is from them that the gold is won.

Bedrock on this claim is mostly schist, but on the lower end of the claim and continuing downstream on the next adjacent claim is a massive, much-fractured, and contorted bluish-white limestone standing at a high angle and cutting transversely across the creek. The schist shows many different phases on the claim that is being mined. In part it is a dark graphitic slaty schist with numerous small veins and stringers of quartz. The bands of this schist are not more than a few feet in thickness and are interlaminated with somewhat calcareous and quartzose schists. Some of the latter schists are rusty yellow in color owing to the decomposition of some of their constituents. The iron mineral from which this limonite had been derived could not be determined, but it was probably in part pyrite. In at least one place on the claim a narrow band of limestone interlaminated with the schist was seen. From this description of the bedrock it is evident that lithologically the rocks are similar to those in the richer parts of the Nome region, in the Iron Creek basin, in the Kougarok, on Ophir and Melsing creeks near Council, in the Solomon and Casadepaga regions, and near Bluff. This resemblance is further strengthened by the relation of the schists at all these places to the heavy bluish-white limestones.

Several hundred ounces of gold from this claim was examined and the coarseness of the pieces was remarkable. Practically no fine gold was found and few if any pieces of the gold recovered were worth less than one-fourth of a cent. Several nuggets worth from $25 to $50 have been found, and while the writer was on the ground one nugget weighing nearly 7 ounces and worth about $125 was picked up in the gravel. In form the gold from this claim is chunky, or in nuggets, but a little wire gold was also seen, though no flaky or scaly gold was observed. The gold is dark but almost never black and shows few signs of recent movement. Although some of the corners have been rounded the gold as a whole does not appear to have traveled far. In fact, many pieces are sharp and angular as if but recently unlocked from the parent ledge. Some of the nuggets have pieces of the country rock still adhering to them. The most abundant mineral attached to the gold is quartz of the same physical aspect as the quartz in the strings and lenses in the schist. Black graphitic slaty schist is also attached to the gold in some of the specimens, and the way in which the gold forms filaments in this rock shows indisputably that some of the placer gold has been derived from this kind of country rock.

Estimates as to the value of this ground are of little use, for the nuggety character of the gold makes the tenor range between wide limits. It is reported that over 190 ounces was cleaned up from about six box lengths shortly before the visit by the Survey geologist, in 1910. At the time of the visit a clean-up of 120 ounces was made from about four and one-half box lengths. This is equal to a bedrock surface of about 500 square feet, so that the production from this cut was nearly $4.50 per square foot of bedrock. A working force of 15 men were able to strip and shovel into sluice boxes this amount of ground in a little over a day. The exact width of the pay streak is not known, for all the work so far has been only on the eastern side of the claim and the western margin of the productive ground has not been reached.

Water for sluicing is obtained from Klery Creek by running a hydraulic hose several hundred feet upstream and bringing the water thus obtained down on as flat a grade as can be maintained. This supply, however, does not furnish an adequate head, so that some other method will have to be used. But slight difficulty should be experienced in obtaining a satisfactory supply, for the volume is ample for the present demands. No accurate measurements of the volume of Klery Creek were made, but the fact that a crossing, even on a riffle, could not be made in less than 2½ feet of water, in a current of such speed that care had to be taken in keeping one's feet, shows that several thousand miner's inches is probably available during a season such as 1910. It should be noted, however, that last year was an abnormally wet one, and estimates based on observations during that time are undoubtedly above the average.

Few assays have been made of gold from this claim, but on a sample submitted to the assayer of the Nome Bank & Trust Co. a fineness of 888½ was determined. This would give a value of $18.37 an ounce.

In the concentrates collected with the gold in the sluice boxes magnetite is the most abundant mineral. This forms a much larger proportion of the concentrates than it does in those near Nome. Together with the magnetite are some ilmenite and a little pyrite and limonite. These iron minerals probably are derived mainly from the greenstones and greenstone schists, although the pyrite and its accompanying limonite may have come from veins in the schists or from the vicinity of the limestone-schist contact, a place frequently mineralized in other regions. Garnet, or so-called ruby, so commonly found in the concentrates from Seward Peninsula, is relatively rare and forms but a small proportion of the black sand. The small amount found is due to the absence of this mineral in the adjacent schists derived from igneous and sedimentary rocks. None of the rare heavy minerals have so far been recognized in the concentrates.

About a mile and a quarter upstream from this claim is another claim, where gold similar in physical character has been found. Work on this ground has been carried on by a crew of only four men and consisted mainly of dam building and bringing up a bedrock drain, so that only a small production had been made and the opportunity of examining a large amount of gold was not afforded. It seems certain, however, that the gold from this claim is of the same chunky character as on the lower claim, although the proportion of fine gold is larger and the nuggets, as a rule, weigh less. From the shape of the gold it is believed that it has not traveled far.

Midway between these two claims the gold is of an entirely different character, although the general geology shows no marked change except that the limestone is more remote and the canyon character of the valley is more pronounced. The gold from a claim in this locality is practically all in fine bright scales. No nuggets worth more than a few cents each have been recovered, though several hundred dollars' worth of gold have been won. The scales are all nearly of the same size, no flour gold being seen. All the flakes are of a bright gold color with no tarnished nor black coating. No pieces with quartz or other foreign material attached were seen. This gold was of the type locally known to the miners as "bar" gold and showed by its physical character that it had traveled much farther from the ledge from which it was derived than the gold either upstream or downstream from this place.

Gold similar to this "bar" gold has also been found downstream from the first-described claim. It is identical in all essential respects with the one just described and has probably had a similar history. The fact that this gold has traveled farther from its parent ledge is indicated by the higher assay value of the gold. It is not possible to give its precise assay value, for the sample that was tested was mixed with nugget gold from one of the claims farther upstream. This mixed sample, however, showed a higher gold content than the nugget gold previously quoted as worth $18.37 an ounce, so the difference is probably to be assigned to the greater fineness of the "bar" gold.

ORIGIN OF THE GOLD.

The distribution of the gold and the differences in the physical character presented by this mineral from the several claims in this stretch of about 2 miles present problems of economic importance. It is believed that the coarse nuggety gold on the two claims has been derived from near-by areas of bedrock and has therefore not traveled far from its source. Possibly some of it had been concentrated in earlier stages of the valley development and was subsequently reconcentrated in the present streams, but the movement of the gold by this process must have been relatively slight. On the other hand, the fine flaky gold found downstream from the areas of coarse gold seems to represent the smaller, lighter particles which, because of their size, have been carried farther from their source. Such a process of sorting is analogous to the well-known distribution of gold in a sluice box, where the larger, heavier particles are found toward the head end of the box and the smaller, lighter pieces near the foot or discharge end. According to this theory there are several localities of mineralization cut by Klery Creek, each being rather close to the areas of heavy gold, whereas in the intermediate regions the stream has not been so close to regions of as great mineralization and the gold has been derived from the areas upstream.

Too little is known about the region to determine beyond question whether the mineralization is confined to a single zone or whether there are a great number of mineralized zones, but from the number of places where gold has been reported in the Squirrel River basin it seems probable that there are at least several and possibly many zones of mineralization. Further study of this important question is necessary, for it affects the future of the region. Not only is it important in determining the probable area in which gold placers may be expected, but the information is also valuable in determining the trends of the placer ground. From the experience in Seward Peninsula it is believed that the contact of the heavy limestone and the graphitic or quartzose schists is one of the most favorable localities for searching for placer deposits in this group of rocks. This experience seems to be borne out in part by the work on Squirrel River, for the richest claim so far discovered has been near this contact. That there are other places where mineralization has been pronounced can not be doubted, and the prospector should therefore not place undue emphasis on the above suggestion.

BENCH GRAVELS.

So far only the shallow creek gravels in the stream beds have been exploited. There are, however, bench and high-level gravels in this region as well as the broad fillings of the main stream valleys which are possible sources of mineral wealth. None of these older gravels have been prospected as yet, and therefore suggestions as to their probable value or character are tentative and subject to revision when more information is obtained. The lower benches already noted as occurring at several different elevations above the tributary streams, such as Klery Creek, seem to have had essentially the same method of formation as the known auriferous creek gravels. It is therefore believed that where these benches have been developed in the neighborhood of bedrock mineralization they will produce placer gold. Most of the benches of this character on Klery Creek had but small length or breadth, so that only discontinuous deposits resulted. Such benches, however, may afford rich pockets of auriferous gravel which would well repay exploitation. Many of the benches seem to be covered with muck and turf, which suggests that the gravels are frozen and will require thawing apparatus.

The higher gravels, which are of wide extent and not only cover the lower slopes of the Squirrel River basin but also extend both up and down stream along the Kobuk, present problems much more difficult to interpret. The origin of these gravels can be determined only by a general survey of a large area in the lower part of the Kobuk Valley supplemented by numerous good sections of the deposits by means of prospect shafts. The character and distribution of these high-level gravels strongly suggest that they have not been formed by normal fluviatile action. There is a possibility that they may mark marine deposition, but it seems more probable that they are the outwash deposits from ancient glaciers that at one time occupied the more eastern part of the Kobuk Valley. If this interpretation is correct, there is small probability that economically profitable placers will be found in these gravels. Although outwash deposits may contain gold, it is believed that normally the valuable minerals are so disseminated that, except under conditions of subsequent concentration, they can not be profitably extracted. These high gravel-plain deposits consist largely of rolled quartz pebbles. No striated fragments or other marks of direct glaciation were observed. The physical condition of these gravels with respect to frost is not known. As a rule, gravel deposits at any considerable elevation above the adjacent streams are so well drained that they are not permanently frozen. At several places where these gravels are exposed in the valley walls of the tributary streams there are indications that they are not frozen. These places, however, do not give conclusive evidence of the conditions of the gravels in the intermediate area between two streams, where the gravels are not exposed to the light and air and where the ground-water level rises so that the gravels are not as well drained. From the character of the surface in some of these areas which are less well drained it seems certain that permanently frozen ground will be encountered.

No prospecting has been done in the deeper gravels that form part of the flood plain of Squirrel River, so that no definite information as to the presence of placer ground there is available. It is understood that prospectors have found colors of gold on many of the bars and in shallow holes which did not reach bedrock. The ground was frozen and the necessary machinery for exploring the deposits was not at hand, so that the deep ground was abandoned for the more easily worked shallow creek diggings. From the experiences on Seward Peninsula it seems questionable whether important placer deposits will be discovered in these flats. It should be reiterated, however, that the data for basing a decision are inadequate, and the above suggestion is little better than a guess warranted only by the desire to prevent the reckless expenditure of time and money on ill-considered projects.

SUMMARY OF CONCLUSIONS.

Taken as a whole, the Squirrel River region is one in which the small amount of prospecting already done has disclosed productive placers. The extent of these has not been determined, but it is believed that the region affords a good opportunity for industrious and capable prospectors. The rigors of the climate and the short working season are against the development of a large camp and should dissuade the incompetent from invading the new district in a "stampede." The similarity of the placers so far discovered to those in the more productive parts of Seward Peninsula gives faith in the future of the region. This belief would be further strengthened if prospecting should show the existence of valuable bench or deep deposits capable of supporting mining during the winter season. A large output in the near future is not expected, but adequate returns for intelligent and competent exploitation are indicated by the present results.

RECENT SURVEY PUBLICATIONS ON ALASKA.

[Arranged geographically. A complete list can be had on application.]

All these publications can be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they can be obtained free of charge (except certain maps) on application.

2. A certain number are delivered to Senators and Representatives in Congress for distribution.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at prices slightly above cost. The publications marked with an asterisk (*) in this list are out of stock at the Survey, but can be purchased from the Superintendent of Documents at the prices stated.

4. Copies of all Government publications are furnished to the principal public libraries throughout the United States, where they can be consulted by those interested.

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Topographic maps.

The following maps are for sale at 5 cents a copy or $3 per hundred:

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Grand Central special, Seward Peninsula; scale, 1:62,500; by T. G. Gerdine.
Nome special, Seward Peninsula; scale, 1:62,500; by T. G. Gerdine.
Solomon quadrangle, Seward Peninsula; scale, 1:62,500; by T. G. Gerdine.

The following maps are for sale at 25 cents a copy or $15 per hundred:

Seward Peninsula, northeastern portion of, topographic reconnaissance of; scale, 1:250,000; by T. G. Gerdine.
Seward Peninsula, northwestern portion of, topographic reconnaissance of; scale, 1:250,000; by T. G. Gerdine.
Seward Peninsula, southern portion of, topographic reconnaissance of; scale, 1:250,000; by T. G. Gerdine.
Seward Peninsula, southeastern portion of, topographic reconnaissance of; scale, 1:250,000. Contained in Bulletin 449. Not published separately.

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