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MINERAL RESOURCES OF ALASKA

REPORT ON PROGRESS OF INVESTIGATIONS IN

1912

BY

ALFRED H. BROOKS AND OTHERS



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MINERAL RESOURCES OF ALASKA, 1912.

By ALFRED H. BROOKS and others.

PREFACE.

By ALFRED H. BROOKS.

The present volume is the ninth of a series of bulletins [1] published annually, treating of the progress of mining in Alaska and summarizing the results achieved during the year in the investigations of the mineral resources of the Territory. In these reports the aim is prompt publication of the most important economic results of the year. The short time available for their preparation does not permit thorough office study of the notes and specimens. Hence some of the statements made may be subject to modification when the researches have been completed. Those interested in any particular district are therefore urged to procure a copy of the complete report on that district as soon as it is available.

In addition to presenting preliminary statements on investigations made during the year, this volume, like those previously issued, summarizes the condition of the mining industry and gives statistics of mineral production. It is intended that this series of reports shall serve as condensed statements of the progress of the mining industry for the years which they cover. The fund available for Alaskan investigations is too small to permit a visit to every mining district each year by a member of the Survey. Therefore the data used in preparing the summary on mining development are in part based on information gleaned from various reliable sources.

Again, as in previous years, the writer is under great obligations to many residents of the Territory for valuable data. Those who have thus aided include many mine operators, engineers, prospectors,

[1] Report on progress of investigations of the mineral resources of Alaska, 1904: U. S. Geol. Survey Bull. 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; Idem, 1910: Bull. 480, 1911; Idem, 1911: Bull. 520, 1912.

Federal officials, and officers of banks and of transportation and commercial companies. It is impossible to enumerate all who have contributed information, but special acknowledgment should be made to the following: The Director of the Mint; Charles D. Garfield, of Juneau; Alaska Mexican Gold Mining Co., Alaska United Gold Mining Co., and Alaska Treadwell Gold Mining Co., of Treadwell; Arthur Thompson, of Katalla; George M. Esterly, of Nizina; Stephen Birch, of Kennecott; Ringwald Blix, of Copper Center; Melvin Dempsey, of Dempsey; H. E. Ellsworth, of Seward; Henry Deyo and O. Roberts, of Valdez; Henry S. Tibbey, of Chignik; Thomas H. Hanmore, of Iliamna; R. W. J. Reed, of Nome; Corey C. Brayton, of Solomon; John A. Dexter, of Golovin; G. A. Adams, of Council; M. F. Moran, of Kiana; E. R. Stivers, of St. Michael; Philip Gallagher, of Nulato; George W. Woodruff, of Fortymile; A. M. Allma, of Miller House; J. J. Hillard, of Eagle; J. A. Kemp, of Steel Creek; T. E. Phillips, of Jack Wade; Frank Slaver, of Woodchopper Creek; Edward H. Boyer, Wells Fargo Co., American Bank, and First National Bank, of Fairbanks; W. B. Ballou, of Rampart; Wm. R. Lloyd, of Kantishna; H. F. Thuman, of Hot Springs; T. M. Thurston, Cyril P. Wood, E. A. Austin, and Charles E. Taylor, of Iditarod; Wm. Babis, of Bethel; and Edward J. Steer, of Georgetown. Besides these, many mine operators have furnished information in regard to mineral production.

The arrangement and manner of treatment in this volume are the same as in those previously issued. Papers of a general character are presented first, followed by those treating of special districts, arranged geographically from south to north. This bulletin contains 12 papers by 10 authors. One of these papers deals with administrative matters, one is a general summary of the mining industry, and the remainder deal more specifically with the economic geology of individual districts. In the geologic papers emphasis is laid on the conclusions that are of immediate interest to the miner, which will, however, be more fully treated in reports now in preparation. The need of prompt publication requires that the illustrations in this volume be of the simplest kind.

ADMINISTRATIVE REPORT.

By Alfred H. Brooks.

INTRODUCTION.

For a number of years Congress recognized the necessity of making the plans for Alaskan investigations far in advance of the opening of the field season by including the annual grant of funds in the first appropriation bill passed. This policy made the money available between the first of January and the middle of February, and thus the plans, including the moving of supplies during the winter, could be carried out economically and efficiently. In 1912 the appropriation for the continuation of the investigations of the mineral resources of Alaska was not made until August 24 and was reduced from $100,000 to $90,000. As a consequence of this delay but little could be accomplished and the projects undertaken could be carried out only at relatively heavy expense. Only three parties out of the twelve eventually dispatched to Alaska had a full season's field work, these being supported up to the end of June by the balance left from the funds of the previous year, and from July 1 to the time the regular appropriation became available by the temporary grants made by Congress. Several other parties were dispatched as these temporary grants permitted, but the funds were so inadequate that the parties were undermanned and but poorly equipped.

In spite of the lateness of the appropriation, it was deemed best, in view of the large number of investigations for which there was urgent need, to undertake certain pieces of work. It was, however, fully realized that this work would be very expensive in proportion to the results which could be achieved.

Twelve parties in all were engaged in surveys and investigations during 1912. Of these, two started in April, one in May, two about the 1st of July, and the others between the 10th and 29th of August. The average length of the Alaska field season in the past has been 110 days; the average of 1912 was only 53 days. Moreover, the parties worked late in the fall, when much time was lost owing to unfavorable weather.

Among the important pieces of work which had to be abandoned were an exploration through the western part of the Colville basin to

Point Barrow and geologic and topographic reconnaissance surveys in the Talkeetna and Broad Pass regions. In preparation for the latter work provisions had been dispatched to Valdez Creek, some 300 miles from the coast, at very heavy expense. A reconnaissance of the Yakataga region and detailed geologic and topographic surveys of the eastern part of the Matanuska coal fields and of the Willow Creek gold district were also plans that could not be carried out.

The twelve parties included ten geologists, two geologic assistants, four topographic engineers, one traverseman, two hydraulic engineers, and fourteen packers, cooks, and other assistants. In addition to this, some gage readers were employed who gave only part of their time to the work. Seven of these parties were engaged in geologic work, three in topographic surveys, and two in the investigation of water resources. The results can be summarized as follows:

The areas covered by geologic reconnaissance surveys, on a scale of 1:250,000 (4 miles to the inch), amount to 2,000 square miles; by detailed geologic surveys, on a scale of 1:62,500 (1 mile to the inch), 525 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 in terms of area. No topographic reconnaissance surveys were made in 1912, but detailed topographic surveys of 298 square miles, on a scale of 1:62,500 (1 mile to the inch), were completed.

In the Yukon-Tanana region 69 gaging stations were maintained in 1912 for an average of 14 weeks each, furnishing data on the water resources of the Fortymile, Eagle, Seventymile, Birch Creek, and Fairbanks districts.

To state the work geographically, one party was in southeastern Alaska, two in the Copper River basin, three in the Prince William Sound region, one on Kodiak Island, three in the Yukon-Tanana region, one in the lower Yukon and Iditarod regions, and one in northeastern Alaska.

Among the important results of the year was a detailed geologic and topographic survey of the mining district near Ellamar and Landlocked Bay, a reconnaissance of the Ruby Creek mining district, and the completion of the geologic survey from Porcupine River northward to the Arctic Ocean. The preliminary investigation of the water resources of the more important mining districts in the Yukon-Tanana region, begun six years ago, was also completed.

The following table shows the allotment, including both field and office expenses, of the total appropriation of $90,000 to the districts investigated. In preparing this table the general office expenses were divided among the districts in proportions determined by the cost of the surveys in each district, allowance being made for variations in the character of the work. The results are expressed in

round numbers. The item "General investigations" includes the cost of working up field data on districts that were not under survey during the year and the cost of collecting the statistics of production. In past years the total funds have always been allotted. In 1912, however, the conditions already referred to made a full season's work impossible and a part of the money was therefore not allotted. This unallotted balance will be used in the preliminary work necessary to carry on the surveys planned for 1913.

Allotment to Alaskan surveys and investigations in 1912.

Southeastern Alaska	$2,000
Copper River region	20,500
Prince William Sound and Kodiak Island	23,800
Yukon basin	15,000
Northeastern Alaska	5,000
General investigations	7,700
Unallotted	16,000
	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 to give the exact figures, as the same party or even the same man may have 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 1912.

Detailed geologic surveys	$15,600
Reconnaissance geologic surveys	3,500
Special geologic investigations	12,000
Detailed topographic surveys	18,200
Investigation of water resources	5,000
Collection of statistics of mineral production	1,100
Miscellaneous, including clerical salaries, administration, inspection, instruments, office supplies, and equipment	18,600
Unallotted	16,000
	90,000

Allotments for salaries and field expenses, 1912.

Scientific and technical salaries	$36,970
Field expenses	18,370
Clerical and other office and miscellaneous expenses	18,660
Unallotted	16,000
	90,000

The following table exhibits the progress of investigations in Alaska 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 in terms of area.

Progress of surveys in Alaska, 1898–1912.

Year.	Appropriation.	Geologic surveys.			Topographic surveys.					Investigations of water resources.	
		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.	Measurements of stream volume.
		Sq. m.	*Sq. m.*	*Sq. m.*	*Sq. m.*	*Sq. m.*	*Sq. m.*	*Miles.*			
1898	$46,189	9,500	.....	.....	12,840	2,070	.....	.....	.....	.....	.....
1899	25,000	6,000	.....	.....	8,690	.....	.....	.....	.....	.....	.....
1900	60,000	3,300	6,700	.....	630	11,150	.....	.....	.....	.....	.....
1901	60,000	6,200	5,800	.....	10,200	5,450	.....	.....	.....	.....	.....
1902	60,000	6,950	10,050	.....	8,330	11,970	96	.....	.....	.....	.....
1903	60,000	5,000	8,000	96	.....	15,000	.....	.....	.....	.....	.....
1904	60,000	4,050	3,500	.....	800	6,480	480	86	19	.....	.....
1905	80,000	4,000	4,100	536	.....	4,880	787	202	28	.....	.....
1906	80,000	5,000	4,000	421	.....	13,500	40	.....	.....	14	286
1907	80,000	2,600	1,400	442	.....	6,120	501	95	16	48	457
1908	80,000	2,000	2,850	604	.....	3,980	427	76	9	53	556
1909	90,000	6,100	5,500	450	6,190	5,170	444	.....	.....	81	703
1910	90,000	.....	8,635	321	.....	13,815	36	.....	.....	69	429
1911	100,000	8,000	10,550	496	.....	14,460	246	.....	.....	68	309
1912	90,000	.....	2,000	525	.....	.....	298	.....	.....	69	381
	1,061,189	68,700	73,085	3,891	47,680	114,045	3,355	459	72	.....	.....
Percentage of total area of Alaska	.....	11.72	12.46	0.66	8.16	19.45	0.57	.....	.....	.....	.....

GEOGRAPHIC DISTRIBUTION OF INVESTIGATIONS.

GENERAL WORK.

The writer was employed in office work of the Alaska division until August 31, when he was appointed vice chairman of the Alaska Railroad Commission. Most of his time from that date to the middle of February was devoted to work of the commission. During this period the administration of the Alaska division was in the hands of George C. Martin, as acting geologist in charge.

The writer, in company with the other members of the commission (Maj. J. J. Morrow, Eng. Corps, U. S. A., chairman; L. M. Cox, civil engineer, U. S. N.; and C. M. Ingersoll), left Washington for Alaska September 2 and returning reached Washington November 27. About two months were devoted to investigations in Alaska, during the course of which Katalla, Kenai Peninsula, the Willow Creek district, Valdez, Cordova, Fairbanks, Chitina, Haines, Skagway, and Juneau were visited. The commission was charged specifically with the duty of investigating the transportation problem and railway routes. Incidentally considerable information on mining development was collected, and this is embodied in the

following pages. The present report does not deal with the work of the commission, the results of which have already been published.[1]

Of the time in the office devoted to Survey work during 1912 the geologist in charge has spent about 20 days in reading and revising manuscripts, 40 days in preparing matter for the progress report, 6 days in writing scientific articles, 4 days in preparing the annual Alaska press bulletin, 7 days on statistics of mineral production, 13 days on field plans, and the remainder on routine and miscellaneous matters.

R. H. Sargent continued the general supervision of the topographic surveys and map compilation in addition to carrying on his own field work. 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 collecting statistics of production of precious metals in Alaska.

Arthur Hollick was employed for about six months and continued the study of the fossil flora of the coal measures of Alaska, a work which, it is believed, will have great economic value in the determination of the stratigraphy of the coal fields.

SOUTHEASTERN ALASKA.

It has long seemed desirable that a geologist specially conversant with building materials should investigate the marble and gypsum deposits of southeastern Alaska. Owing to the conditions already described it was possible to make an allotment for this purpose in 1912, and E. F. Burchard was temporarily transferred to the Alaska division to carry on this work.

Mr. Burchard left Seattle August 29 and spent a month in visiting the known deposits of marble and gypsum in southeastern Alaska. A summary of his results is presented on pages 52–77 of this volume. C. W. Wright was employed for about two months and a half during the summer in completing the preparation of his report, "Geology and ore deposits of Copper Mountain and Kasaan Peninsula, Alaska." This report has been submitted for publication.

COPPER RIVER REGION.

The rapid mining development in the Kotsina-Chitina copper belt made it imperative that the detailed survey and investigation of this field should be extended. As a part of this project, it was decided to begin a detailed survey of the west end of the belt, and this work was assigned to two parties, but the delay in the enact-

[1] Report of the Alaska Railroad Commission, Part I: H. Doc. No. 1346, 63d Cong., 3d sess., pp. 172, with 8 maps; 1913, Part II: S. Doc. No. 1346, 63d Cong., 3d sess., maps and profiles, 1913.

ment of the law carrying the appropriation prevented a full season's work.

D. C. Witherspoon, assisted by S. A. Witherspoon, began topographic work in this field on July 19 and continued until September 30, completing the areal mapping of some 80 square miles on a scale of a mile to the inch, with contour intervals of 100 feet. This mapping covered part of an important copper-bearing district and will be extended westward in 1913.

The geologic mapping and study of the ore deposits of this district were assigned to F. H. Moffit, assisted by Theodore Chapin and J. B. Mertie. The funds were not sufficient to permit work by a separate geologic party, and therefore Mr. Chapin was detailed to accompany Mr. Witherspoon and do such work from his camp as circumstances permitted. Mr. Moffit and Mr. Mertie spent about three weeks in September in the same district but were prevented from continuing the work by the lack of provisions and feed for stock, the railroad to Cordova being blocked for some six weeks. The Moffit party mapped in all about 65 square miles, but another season's work will be required to extend the geologic survey over the economically important part of the district and to investigate the many prospects and mines. The final report on this investigation can be prepared only after further work, but a brief summary of some of the results is presented on pages 81–85 of this report.

PRINCE WILLIAM SOUND.

The detailed topographic mapping of what was then the most important part of the Valdez district was completed by J. W. Bagley in 1911. Since that time valuable prospects have been discovered west of the mapped area, and it therefore seemed desirable to extend work in this field. Mr. Bagley was detailed for this work and was employed on it from August 30 until October 23, mapping 128 square miles, for publication on a scale of 1 mile to the inch, with 50-foot contours.

The region immediately tributary to Landlocked Bay and Ellamar is one of the best-developed copper-bearing districts of Prince William Sound. For this reason a detailed geologic and topographic survey seemed desirable. The topographic work was assigned to R. H. Sargent, assisted by C. E. Giffin. Work was begun August 26 and continued until October 13. A total of 90 square miles, for publication on a scale of a mile to the inch, with 100-foot contours, was mapped.

S. R. Capps and B. L. Johnson were assigned to make geologic surveys of the same district. They began work August 26 and continued until October 9, making, a detailed geologic survey and investigation of mineral deposits in an area of some 60 square miles. The

more important economic results of this investigation are presented in this volume (pp. 86–124), and the final report is in preparation. At the close of the season Mr. Johnson paid a hasty visit to some of the better-developed properties of the region tributary to the town of Seward.

KODIAK ISLAND.

In the aggregate there has been a large amount of prospecting for auriferous lodes on Kodiak Island, and this, together with the fact that considerable mining is done each year on the beach placers, made an investigation of the resources of the island desirable. Plans for carrying on this work systematically in the summer of 1912 were formulated but owing to the delay in the appropriation could not be executed. An additional deterrent was the volcanic eruption of June 6 to 8, which in many places covered outcrops with large quantities of volcanic tuff. Furthermore, an investigation of this volcanic eruption was desirable, not only for its scientific interest but also because of the bearing it had on the industrial advancement of this part of the territory. The Geological Survey had no funds which could be devoted to this purpose, but the National Geographic Society made a grant through which it was possible to dispatch George C. Martin to this field. Mr. Martin spent about a month in investigating the distribution of the volcanic tuff and later undertook such observations on the occurrence of metalliferous deposits in the island as circumstances permitted, being occupied from July 4 until September 4 in this investigation. His results relating to the mineral deposits of Kodiak Island are presented on pages 125–136.

THE YUKON BASIN.

The investigation of the water resources in the Yukon-Tanana region, which was begun at Fairbanks in 1907, was continued in 1912. C. E. Ellsworth and R. W. Davenport began work in the Fortymile district on May 20. Later Mr. Ellsworth extended the investigation through the Circle and Fairbanks district, while Mr. Davenport continued stream gaging in the Fortymile district. This work was continued until September 15. During the season 20 gaging stations were maintained in the Fortymile district for an average of 11 weeks each, and 106 measurements were made. The results give information regarding the run-off of about 6,000 square miles. In the Eagle and Seventymile districts 13 gaging stations were maintained for an average of 15 weeks each, and 70 measurements were made. The results give data relating to the run-off of about 600 square miles. Some 20 gaging stations were maintained in the Birch Creek district for an average of 14 weeks, and 123 measurements were made. This investigation indicates the run-off from about 2,150 square miles.

In the Fairbanks district 16 gaging stations were maintained for an average of 14 weeks, and 82 measurements were made. The data thus obtained give information in regard to the run-off of about 2,000 square miles.

Investigation of the surface water supply of the Yukon-Tanana region has now been carried on for six years in the Fairbanks district, five in the Birch Creek, three in the Fortymile, and two in the Hot Springs and Rampart districts, besides which some miscellaneous measurements have been made. The results obtained are of course entirely inadequate to furnish detailed information regarding the run-off of all the streams in this region. Moreover, none of the stations have been maintained long enough to yield reliable data on run-off. It is believed, however, that the stream-gaging data this winter are sufficient to serve as a guide to the placer miner. In view of the urgent demand for investigations of water supply in other parts of the Territory, the work in the Yukon-Tanana region will be discontinued for the present. The results of the investigations by Mr. Ellsworth and Mr. Davenport in 1912 are presented on pages 203–278. A complete report on the work in this region is in preparation.

The rapid development in lode mining in the Fairbanks district since the detailed surveys were completed two years ago made it desirable that further investigations be made. For this reason P. S. Smith was detailed to go to Fairbanks and investigate the auriferous lode deposits in such detail as time permitted. Mr. Smith spent from September 7 to 25 in this investigation. His results are presented on pages 137–202.

Many demands have been made on the Survey for an investigation of the Ruby placer district, and the work was undertaken in 1912, but the circumstances already recounted did not make it possible to put a large party in this field. H. M. Eakin, however, was detailed for the purpose of investigating the Ruby district and also to supplement previous investigations in the Innoko and Iditarod districts. Mr. Eakin reached Ruby July 18 and, after examining this district, made an overland trip to Innoko and the Iditarod, traveling on foot and without packhorses. The principal results of Mr. Eakin's investigation are presented on pages 279–303 of this volume, and a more elaborate report is in preparation.

NORTHEASTERN ALASKA.

By courtesy of the boundary commissioner, Mr. O. H. Tittmann, the Survey was enabled to continue its geologic investigations along the international boundary north of Porcupine River. A. G. Maddren, assisted by J. M. Jessup and G. L. Harrington, was detailed for this work. Field work was begun June 14 and continued until August 25. The topographic maps prepared by the boundary sur-

veyors (scale 1:45,000) were used as a basis and the areal mapping covered 400 square miles. In the course of two seasons Mr. Maddren has in this way carried a geologic survey from Porcupine River northward to the Arctic Ocean, covering an area of about 800 square miles. This work will do much to help elucidate some of the general geologic problems of Alaska. Dr. R. W. Brock, director of the Geological Survey of Canada, had agreed to carry the work southward from the Porcupine to the Yukon. As this work also has been finished, fairly complete information has thus been collected regarding the geology of a belt stretching northward from the Yukon near Eagle to the Arctic Ocean, a distance of nearly 400 miles. Reports on the results of these investigations are now in preparation.

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, but the work of collecting statistics is still much hampered and the accuracy of the results is impaired by the failure of many operators of placer mines to return the statistical schedules mailed to them each year. The funds available for this work are not sufficient to permit sending a geologist each year to every district and obtaining the data desired by personal conference. Therefore, were it not for the aid rendered by the residents of the Territory in making up the estimates of gold production (see pp. 19, 27–29), it would be impossible to present even approximate figures for the gold output of many of the placer districts. The neglect of operators to furnish information on production injures the mining industry by decreasing the accuracy of the published totals for each district. This failure to make returns is not justifiable, as replies are held absolutely confidential, the figures being used only to make up totals. This is practically the only phase of the Survey's Alaskan work which has not had the full support of nearly every mining man with whom the Survey men have come into contact. It is the earnest hope of the writer that all the placer miners of the Territory will soon realize not only that they are running no risk in furnishing to the Survey figures showing production but that in withholding them they are injuring the mining industry.

PUBLICATIONS.

During 1912 the Survey published one professional paper, six bulletins, and one map relating to Alaska. Six bulletins and one water-supply paper are in press. In addition to these, the authors' work

on four other bulletins and one professional paper has been completed, and these publications will soon be sent to press. Six other reports are in preparation.

REPORTS ISSUED.

PROFESSIONAL PAPER 69. The earthquakes at Yakutat Bay, Alaska, in September, 1899, by R. S. Tarr and Lawrence Martin.

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

BULLETIN 498. Headwater regions of Gulkana and Susitna rivers, Alaska, with accounts of the Valdez Creek and Chistochina placer districts, by F. H. Moffit; including geologic and topographic reconnaissance maps.

BULLETIN 500. Geology and coal fields of the lower Matanuska Valley, Alaska, by G. C. Martin and F. J. Katz; including detailed geologic and topographic maps.

BULLETIN 501. The Bonnifield region, Alaska, by S. R. Capps; including geologic and topographic reconnaissance maps.

BULLETIN 504. The Sitka mining district, Alaska, by Adolph Knopf.

BULLETIN 520. Mineral resources of Alaska (report on progress of investigations in 1911), by Alfred H. Brooks and others; including general map of Alaska showing distribution of metalliferous deposits.

REPORTS IN PRESS.

BULLETIN 502. The Eagle River region, southeastern Alaska, by Adolph Knopf; including detailed geologic and topographic maps. (Issued March 17, 1913.)

BULLETIN 525. A geologic reconnaissance of the Fairbanks quadrangle, Alaska, by L. M. Prindle, with a detailed description of the Fairbanks district by L. M. Prindle and F. J. Katz and an account of lode mining near Fairbanks by P. S. Smith; including reconnaissance and detailed geologic and topographic maps. (Issued June, 1913.)

BULLETIN 526. Coastal glaciers of Prince William Sound and Kenai Peninsula, Alaska, by U. S. Grant and D. F. Higgins. (Issued June, 1913.)

BULLETIN 532. The Koyukuk-Chandalar region, Alaska, by A. G. Maddren; including topographic and geologic reconnaissance maps. (Issued June, 1913.)

BULLETIN 533. Geology of the Nome and Grand Central quadrangles, Alaska, by F. H. Moffit; including detailed topographic and geologic reconnaissance maps. (Issued August, 1913.)

BULLETIN 534. The Yentna district, Alaska, by S. R. Capps; including topographic and geologic reconnaissance maps. (Issued June 17, 1913.)

WATER-SUPPLY PAPER 314. Surface water supply of Seward Peninsula, Alaska, by F. F. Henshaw and G. L. Parker, with a sketch of the geography and geology by P. S. Smith and a description of methods of placer mining by Alfred H. Brooks; including topographic reconnaissance maps. (Issued May 28, 1913.)

REPORTS COMPLETED, FOR WHICH ILLUSTRATIONS ARE BEING PREPARED.

A geologic reconnaissance of a part of the Rampart quadrangle, Alaska, by H. M. Eakin (Bull. 535); including geologic and topographic reconnaissance maps. (Issued June 27, 1913.)

The Noatak-Kobuk region, Alaska, by P. S. Smith (Bull. 536); including topographic and geologic reconnaissance maps.

Geologic reconnaissance of the Circle quadrangle, Alaska, by L. M. Prindle (Bull. 538); including topographic and geologic reconnaissance maps.

The Hanagita-Bremner region, Alaska, by F. H. Moffit (Bull. —); including topographic and geologic reconnaissance maps.

REPORTS IN PREPARATION.

Geology and ore deposits of Copper Mountain and Kasaan Peninsula, Alaska, by C. W. Wright; including detailed geologic and topographic maps.

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

Geology and mineral resources of the Ellamar district, Prince William Sound, Alaska, by S. R. Capps and B. L. Johnson; including geologic and topographic detailed maps.

Geology of the region along the international boundary from Porcupine River to the Arctic Ocean, by A. G. Maddren; including detailed geologic maps.

Contributions to the geology of Kenai Peninsula, Alaska, by G. C. Martin, B. L. Johnson, and U. S. Grant; including geologic and topographic reconnaissance maps.

The Ruby-Iditarod region, Alaska, by H. M. Eakin; including geologic and topographic reconnaissance maps.

The surface water supply of the Yukon-Tanana region, Alaska, by C. E. Ellsworth and Royal W. Davenport.

Four topographic maps were issued as illustrations to reports (see p. 16), of which one was on a scale of 1:62,500 (1 mile to the inch) and three on a scale of 1:250,000 (4 miles to the inch). In addition to these, a general map of Alaska showing the distribution of mineral resources was published as an illustration to Bulletin 520. This map was also issued separately as a publication to be placed on sale. Four reconnaissance and three detailed topographic maps are included in the reports that are in press.

THE MINING INDUSTRY IN 1912.

By Alfred H. Brooks.

GENERAL CONDITIONS.

Metalliferous mining in Alaska made important advances during the year 1912. The output of the gold placers was less than in 1911, but the installation of large plants, notably of dredges, in many districts augurs well for the future of this industry. Progress was made in lode gold mining in most of the auriferous districts of the Territory. The output of gold from lodes was greater than in any previous year and probably will double before many years. Copper mining also advanced, partly because several large plants increased their output and partly because a number of small mines were opened on account of the high price of copper. A little oil was produced in the Katalla field, as in the previous year, and the exploitation of marble and gypsum deposits continued in southeastern Alaska. The development of the coal fields still awaits the establishment of a definite policy in regard to the disposition of the public coal lands. The delay in securing cheap fuel for the Territory has now for many years caused a stagnation in many industries. Railway construction and, to a certain extent, railway operation have stopped and many mining enterprises have been hampered if not entirely abandoned on account of the unsatisfactory condition of the fuel problem. Very few Alaskans have any direct interest in coal claims or in mining, but the entire population of the Territory is desirous of seeing the coal fields opened because it is believed that this will bring about advancement in many other industries. Above all, it will encourage the operation and construction of railways, which are of the highest importance to the Territory.

In point of increase in production over previous years copper mining was of first importance in 1912. Several new copper mines were opened in the Prince William Sound region, and development work was actively pushed in the Ketchikan and Kotsina-Chitina districts. There was also a considerable increase in the output of the auriferous lodes compared with that of the previous year. Several lode mines which will be provided with large reduction plants are being opened in the Juneau district. Many smaller lode-mining enterprises were

developed in 1912, notably in the Fairbanks district, on Kenai Peninsula, in the Port Valdez district, and in the Willow Creek district. Promising lode discoveries were made at Port Wells, on Prince William Sound, and the far lesser amount of lode prospecting done in the Innoko-Iditarod region yielded encouraging results.

Though the production from placers at Fairbanks fell off compared with the preceding year, this continues to be the most important placer camp of the Territory. The output of the Iditarod-Innoko region and of the Nome and other districts of Seward Peninsula was about the same as in 1911. The most hopeful feature of the placer-mining industry was the continuation of the installation of dredges. Thirty-eight dredges were operated in Alaska during 1912, three in the Fortymile district, one each in the Fairbanks, Birch Creek, Iditarod, and Kenai Peninsula districts, and the rest on Seward Peninsula. Besides these a number of others were under construction.

PRODUCTION.

The value of the total mineral production in 1912 is estimated at $22,537,821; in 1911 it was $20,691,241. The following table shows the sources of this wealth for the two years and the gain or loss in 1912. The statistics for 1912 are not yet completed and the figures given in the table may be subject to change. The output of marble, tin, gypsum, lead, and other minor products is given under a single item, because a separate listing might reveal the production of individual properties.

Mineral production of Alaska, 1911–12.

	1911		1912		Increase (+) or decrease (−).	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Gold.....ounces..	815,276	$16,853,256	[a] 829,435	$17,145,951	+ 14,159	+ $392,695
Silver.....do....	460,231	243,923	[a] 515,186	316,839	+ 54,955	+ 72,916
Copper.....pounds..	27,267,878	3,408,485	29,230,491	4,823,031	+1,962,613	+1,414,546
Coal.....short tons..	900	7,200	200	2,000	− 700	− 5,200
Marble, gypsum, tin, lead, petroleum, etc.....	.....	178,377	.....	250,000	.....	+ 71,623
	.....	20,691,241	.....	22,537,821	.....	+1,946,580

[a] Preliminary estimates.

NOTE.—In the above table copper is valued at 12.5 cents a pound for 1911 and 16.5 cents for 1912; silver at 53 cents an ounce for 1911 and 61.5 cents for 1912.

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, 1880–1912.

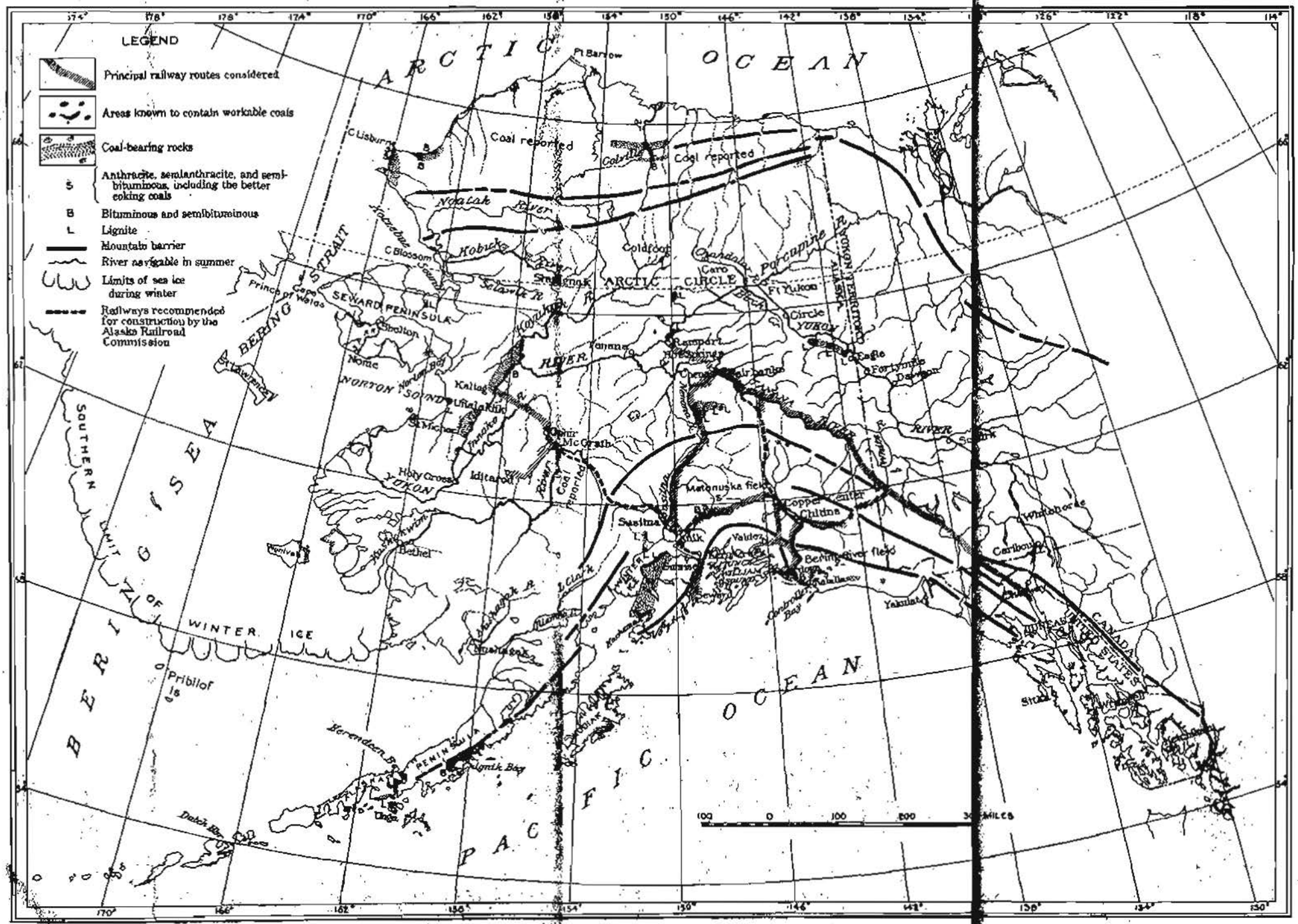
By years.				By substances.	
1880–1890	$4,686,714	1902	$8,400,693	Gold	$212,765,727
1891	916,920	1903	8,941,614	Silver (commercial value)	1,841,202
1892	1,096,000	1904	9,567,135	Copper	13,570,225
1893	1,048,570	1905	16,478,142	Coal	347,389
1894	1,310,257	1906	23,375,008	Marble, gypsum, tin, lead, etc	982,554
1895	2,386,722	1907	20,847,055		
1896	2,980,087	1908	20,142,272		229,507,097
1897	2,538,241	1909	21,141,019		
1898	2,585,575	1910	16,887,244		
1899	5,703,076	1911	20,691,240		
1900	8,238,294	1912[a]	22,537,821		
1901	7,007,398				
			229,507,097		

[a] Preliminary estimate.

TRANSPORTATION.

With the development of Alaska the inadequacy of the present means of transportation becomes more and more evident. While the Kuskokwim and Yukon river systems of Alaska afford some 5,000 miles of navigable water, this is available for only about three and a half months in the year. Moreover, to utilize this means of communication a long, circuitous route to the mouths of these two rivers is necessary, so that transportation by these routes is both expensive and time robbing.

The Yukon and Kuskokwim basins are separated from the open waters of the Pacific by a series of mountain ranges which afford a serious barrier to inland travel. These ranges are, however, broken by several river valleys and by many passes, and through some of these openings three railways have been built and many others projected. Of the existing lines the White Pass Railway alone reaches the Yukon, about 100 miles from tidewater, but in the headwater region of the river and in Canadian territory. From its northern terminal a river journey of 1,400 miles is necessary to reach Fairbanks, the largest inland settlement. The main line of the Copper River Railway extends inland toward Fairbanks for 132 miles and is over 300 miles from navigable waters of the Yukon. As an inland freight carrier this road therefore serves only the lower Copper River basin. The Alaska Northern Railway has been built for 72 miles from its coastal terminal, about 115 miles from the Susitna Valley, 350 miles from the Kuskokwim Valley, and 390 miles from the Tanana at Fairbanks. This line at present serves only the northern part of Kenai Peninsula and Turnagain Arm. In 1912 the White Pass Railway was operated throughout the year and the Copper River Railway for most of the year. The latter was blocked for six weeks in the fall by heavy rock slides and suffered shorter interruptions in summer by floods and in winter by snowslides. Traffic on the Alaska Northern Railway has not been sufficient to warrant winter operation.



MAP OF ALASKA, SHOWING RAILWAY ROUTES FROM THE PACIFIC SEABOARD TO THE YUKON AND KUSKOKWIM.

Besides these railways, which may be considered trunk lines or the beginnings of them, there are about 125 miles of railway on Seward Peninsula, only a small part of which was operated in 1912. It is reported that some of the railway companies of Seward Peninsula could not afford to operate their lines because of the Federal tax of $100 a mile. The Tanana Valley Railway, 46 miles long, connecting Fairbanks with the adjacent mining camps, was operated throughout the year. The following table furnishes in concise form data in regard to existing railways in Alaska:

Railways in Alaska.

	Miles.
Southeastern Alaska:	
White Pass & Yukon route, Skagway to White Pass (narrow gage). Terminal at White Horse, Yukon Territory; total mileage, 102 miles	20.4
Yakutat Southern Ry., Yakutat to Situk River (narrow gage) (not a public carrier)	9.0
Copper River: Copper River & Northwestern Ry., Cordova to Kennicott (standard gage)	195.0
(The same company has built a few miles of track at Katalla, where the Alaska Pacific Ry. was laid in 1907, and some work was previously done at Valdez, on the Copper River & Northwestern Ry., on the Valdez & Yukon Ry., and on the Alaska Home Ry.)	
Kenai Peninsula: Alaska Northern Ry., Seward to a point near head of Turnagain Arm (standard gage)	71.6
Yukon Basin: Tanana Valley Ry., Fairbanks and Chena to Chatanika (narrow gage)	46.0
Seward Peninsula:	
Seward Peninsula Ry., Nome to Shelton (narrow gage)	80.0
Paystreak branch, Seward Peninsula Ry. (narrow gage)	6.5
Council City & Solomon River Ry., Council to Penelope Creek (standard gage)	32.5
Wild Goose Ry., Council to Ophir Creek (narrow gage)	5.0
	466.0

As this volume may reach those who have not received the report of the Alaska Railroad Commission, it has been thought desirable to present the following extract,[1] which summarizes the results and conclusions of the commission. This matter is illustrated by the map (Pl. I).

Less than five months ago the Alaska Railroad Commission was appointed to investgate the problems of transportation in Alaska, involving the comparative study of a dozen terminals and railway routes aggregating over 3,000 miles [Pl. I], and was directed to submit its report "on or before the 1st day of December, 1912, or as soon thereafter as practicable." This duty involved a consideration not only of the physical and engineering features connected with each project, but also the various industrial phases of no less importance. The great mass of data has been digested

[1] Report of Alaska Railroad Commission: 63d Cong., 3d sess., H. Doc. No. 1346, pp. 135-141, 1913.

and the results are presented in the preceding pages. It remains to summarize these results briefly and to present the conclusions of the commission.

The data presented show that the United States possesses in Alaska a frontier territory of great size and of wonderful industrial possibilities. The commission believes that its climate is favorable to permanent settlement and to agriculture, and its mineral resources are vast and as yet but little exploited; that its population is sparse, but only by reason of its inadequate transportation facilities; and that its people are of the same type of hardy pioneers that have carried the United States frontier to its present limits.

In arriving at conclusions and formulating findings the commission has had in mind the terms of the act of Congress constituting its precept, which, briefly stated, provides for recommendations in respect to the best and most feasible railroad routes in Alaska from the seaboard to the coal fields and to the interior navigable waterways, "which will best develop the country resources thereof for the use of the people of the United States." It interprets this precept to mean recommendations—

1. For a railway or railways which give promise of affording the lowest transportation cost to tidewater of coal from one or both of the two best coal fields.

2. The projection of railways along such route or routes as would open the interior to commerce and colonization; the selection of such route or routes to be made after giving due weight to lowest cost and shortest time of construction, maximum economy of operation, and service to the largest areas of known natural wealth, best adapted to permanent colonization; and, finally,

3. That these proposed railways must be based on the best ocean terminals.

The provisions of the enacting clause clearly compel the commission to make choice of routes solely on the basis of physical and economic facts. It therefore can not admit as factors in the problem the existence of railways already built, except in so far as these lines meet the conditions prescribed above. Nor can the local interests of existing coastal settlements be given weight, and still less the personnel or organization of corporations owning interests in existing lines or terminals. The commission conceives its duty to lie in pointing out the route or routes which will best accomplish the ends specified in the acts, without regard to local, corporate, or individual interests.

The routes considered by the commission fall into three classes:

First, those which reach the interior but do not give access to either of the two principal coal fields. In this class are the Skagway route, the Haines-Fairbanks route, the Iliamna-Kuskokwim route, and the Valdez-Fairbanks route.

Second, routes which reach the coal fields only. In this class the routes from Katalla and Controller Bay fall.

Third, the routes which reach the interior and at the same time will furnish economical transportation for the two coal fields. In this class are the Cordova-Fairbanks route, the Seward-Fairbanks route, and the Seward-Innoko-Iditarod route.

These routes will be considered in the order above presented.

For convenience in discussing the relative merits of the various routes under consideration it has been deemed expedient to arrange the physical and economic characteristics of each in such form as to facilitate comparison. Accordingly, two tables have been prepared and are here inserted. Table A shows the various features of the the six through or trunk routes, while Table B refers to the proposed coal roads. The headings of the different columns are descriptive of the data furnished and therefore require no further explanation.

TABLE A.—*Comparison of trunk lines.*

Name of route.	New track mileage.	Existing track mileage.	Total cost of new construction.[a]	Average cost of construction per mile.	Maximum grade (per cent).		Number of summits.	Total lift, north bound.	Average freight rate per ton mile, in cents.	Average rate per passenger mile, in cents.	Through freight rate per ton.	Through passenger rate.
					North bound.	South bound.						
Haines-Fairbanks.	638	.....	$28,186,000	$44,300	[b]2.00	[b]2.00	2	[b]4,000	(c)	(c)	(c)	(c)
Cordova-Fairbanks.....	313	132	13,971,000	44,600	1.13	1.51	1	4,260	[d]8.30 [e]5.49	[d]7 [e]6	[d]$36.94 [e]24.43	[d]$31.15 [e]26.70
Valdez-Fairbanks.	380	.....	18,545,000	48,800	3.00	3.00	3	3,970	[d]9.13 [e]6.04	[d]7 [e]6	[d]34.69 [e]22.95	[d]26.60 [e]22.80
Seward-Fairbanks	391	72	17,708,000	45,300	2.3	2.2	3	4,900	[d]8.55 [e]5.64	[d]7 [e]6	[d]40.20 [e]26.71	[d]32.90 [e]28.20
Seward-Iditarod...	344	72	17,970,000	52,300	[b]2.00	[b]2.00	(f)	(f)	[d]16.5 [e]11.63	[d]10 [e]6	[d]68.64 [e]48.38	[d]41.60 [e]33.28
Iliamna-Kuskokwim.....	400	.....	22,199,000	55,400	(f)	(f)	(f)	(f)	(c)	(c)	(c)	(c)

[a] Cost of new construction contains equipment and overhead charges.
[b] Estimated from United States Geological Survey topographic maps.
[c] No operation studies made.
[d] Rate taken from estimate No. 2 (private construction).
[e] Rate taken from estimate No. 3 (government construction).
[f] Not known.

TABLE B.—*Comparison of coal lines.*

[Freight rate is calculated for 1,500 tons daily output at mines.]

Name of route.	New track mileage.	Existing track mileage.	Total cost of new construction.[a]	Average cost of construction per mile.	Maximum grade (per cent).		Number of summits.	Total lift, south bound.	Average freight rate per ton mile, in cents.	Through freight rate.	
					North bound.	South bound.				Mines to terminal.	Mines to ship.
								Feet.			
Bering River-Katalla-Cordova.....	55	38	$2,700,000	$49,000	1.3	0.58	....	145	1.39	$1.29	$1.54
Bering River-Lake Charlotte-Cordova.....	38	38	2,054,000	54,000	1.3	1.7	1	360	1.57	1.19	1.44
Bering River-Katalla Bay.....	31	.....	[b]1,702,000	55,000	1.3	.58	....	145	2.45	.76	.96
Bering River-Controller Bay.....	25	.....	[b]1,430,000	57,000	1.3	.58	....	145	2.79	.69	.89
Matanuska-Chitina-Cordova.....	163	132	8,434,000	51,700	1.13	2.2	1	2,180	1.66	4.90	5.15
Matanuska-Kern Creek-Seward.....	115	72	4,945,000	43,000	2.3	2.2	2	1,750	1.35	3.10	3.35
Matanuska-Valdez.....	230	.....	12,662,000	55,000	3.0	3.0	3	3,980	1.70	3.91	4.16

[a] Cost of new construction contains equipment and overhead charges.
[b] Exclusive of terminal, which is estimated at $2,500,000.

Of the routes that do not reach either of the principal coal fields, two have their coastal terminals in southeastern Alaska—namely, at Skagway and at Haines, Pyramid Harbor. These two routes have much in common, but as between the two harbors the location at Haines, with its possibilities of development on both sides of the peninsula and with its good anchorage area, possesses advantages over Skagway.

The commission believes that a railroad will be built at an early date connecting Haines with the Canadian interior, for the development of local resources, and that the development of central Alaska and adjacent portions of Canada will ultimately call

for an extension of this line into the Tanana Valley and possibly on to the Seward Peninsula. The route presents many attractive features, but, in common with the route based on Skagway, the mileage to Fairbanks is excessive, is partly in foreign territory, and as yet no high-grade coal has been discovered which can be conveniently served by either of these routes. The commission therefore feels justified in confining its further considerations to the routes reaching the interior from ports on the Gulf of Alaska west of the one hundred and forty-first meridian.

The third route which does not give access to either of the principal coal fields is the route from one of the harbors on Cook Inlet into the valley of the Kuskokwim. These harbors may be passed over with the statement that no railroad can be based on any of them that will assist in the development of the Territory as efficiently or as economically as can be done by lines reaching the coast farther north and east. They lie too far southwest to develop conveniently the known resources of the interior. The commission, however, desires to state that Iliamna Bay or Iniskin Bay have possibilities for use as a terminal for a short line intended to develop the resources and industries of the immediately tributary region. This eliminates all routes to the interior that will not economically serve either of the two principal coal fields, excepting the route from Valdez.

Valdez has a harbor inferior only to that of Cordova and about equal to that of Seward. There is no probability, however, of its being utilized as an outlet for either Bering River or Matanuska coal. The commission considered the possibilities of developing Matanuska coal by way of this port, but the haul involves the surmounting of two major summits (Tahneta and Thompson passes) and one minor summit (Ernestine), besides being longer in distance than the haul over the alternate route to Seward. It is not surprising, therefore, that operating costs are shown to be excessive. With industrial advancement it is probable that Valdez will require the construction of one or the other of the lines connecting it with the Copper River valley. The Thompson Pass route would also have value in case equitable trackage arrangements for traffic through to tidewater can not be effected by the proposed Chitina-Fairbanks road.

This leaves for consideration the routes giving economical access to the two coal fields. Before discussing these routes which are affected by the development of these fields it is desirable to briefly consider the coal question.

In the absence of information to the contrary, the commission assumes that the coal deposits of the Bering River and Matanuska fields are on a parity as to quality of product and cost of mining. The heart of the Bering field lies about 30 miles from the coast at either Katalla or Controller Bay, about 76 miles from Cordova, and about 38 miles from the existing tracks of the Copper River & Northwestern Railway. The heart of the Matanuska field is 187 miles from Seward, 115 miles from the present northern terminus of the Alaska Northern Railway. Both fields are reported to contain bituminous coal of good coking and steaming quality, in composition approximating the best coals of the eastern fields in the United States, but both are so folded and crushed as to add to the expense of mining and to much reduce the percentage of lump in the output.

It has been shown by analyses of operation costs (see p. 23) that these coals can probably be delivered at their respective terminal points for the following figures per ton. These figures are based on an assumed output of about 500,000 tons annually and include only transportation and terminal costs.

Estimate of cost of transporting and loading coal.

	Per ton.
Bering River coal to Katalla	$0.96
Bering River coal to Controller Bay	.89
Bering River coal to Cordova via Lake Charlotte	1.44
Matanuska coal to Seward	3.35

The coal markets of the Pacific have also been discussed, and it has been shown that Alaska coal could probably compete with other coals in the west-coast markets provided that the operators both of the mines and of the transportation lines are content with reasonable profits.

Controller Bay and Katalla each require for terminal development a first cost of construction that will assuredly be high and will certainly require high maintenance charges. Moreover, the completion of such terminal would offer harbor facilities very inferior to those that can at little expense and at low maintenance charge be had at Cordova. While the costs of transportation to these points are lower than that to Cordova, the commission believes that for the reasons cited above and discussed more fully elsewhere (see pp. 96–98), it would be unwise to attempt harbor construction at either Katalla or Controller Bay at present. An additional and important reason for this decision lies in the fact that if either of these places were developed as a coal-shipping port, all Bering River coal used in Alaska would have to be transshipped unless a line from Katalla to a junction with the Copper River Railway were built. It is evident that such a railway would serve, for the present at least, to make harbor construction at either Katalla or Controller Bay superfluous, for it would at once give the coal an outlet to tidewater at Cordova, as well as inland by the Copper River valley.

The commission is of opinion that the routes based on Skagway, Haines, Iliamna Bay, and Valdez are eliminated for the lack of high-grade coal, and those based on Katalla and Controller Bay by the present unsuitable harbor facilities, which would be remedied only by difficult and costly construction. This reduces the discussion to the three routes which penetrate inland Alaska and at the same time give convenient access to the two coal fields. Two of these routes reach the heart of the Tanana Valley—one from Cordova and one from Seward. The third reaches the Kuskokwim from Seward. The two routes into the Tanana will first be compared.

After its study of all available harbors, the commission is of the opinion that the one at Cordova is, without question, the best. It has no disadvantage not possessed by all and one great advantage possessed by no other—namely, an ample area of good anchorage. Seward is evidently the seaport for the Matanuska coal and Cordova the logical outlet for the Bering River coal. The comparisons of transportation rates given in the foregoing table show that for an output of 500,000 tons annually it will cost $1.91 a ton more to haul Matanuska coal to Seward than it will to haul the Bering River coal to Cordova, and the analysis further shows that for double this output the additional cost will be $1.11. This places the Matanuska coal at such disadvanage that it could probably not be marketed at tidewater in competition with the Bering River coal.

To now consider the trunk lines to Fairbanks over their two routes. For the purpose of comparison a digest of the analyses of mileage and cost of new construction, mileage between terminals, and freight rates on these two lines is here again presented:

Terminals.	Distance (miles).	New mileage.	Cost of new construction.	Average freight rate per ton.	
				Estimate 2.[a]	Estimate 3.[b]
Cordova and Fairbanks	445	313	$13,971,000	$36.94	$24.43
Seward and Fairbanks	463	391	17,708,000	40.20	27.71

[a] Construction by private corporations. [b] Construction by the Government.

It is evident that on the Cordova route the first investment will be less than on the Seward route; the resulting freight rates will be lower; the terminal port offers a better

harbor than the one at Seward; and the tributary coal field promises the earlier development because its product can be marketed cheaper. Each of these economic features points clearly to the advisability of reaching the Tanana Valley via the valley of the Copper River, and the commission therefore recommends the construction of a railway from Chitina to Fairbanks.

The construction of a railway through the Copper River valley to the Tanana would leave a large and very important part of Alaska unprovided for. It would in no way furnish transportation facilities to the rich agricultural lands and mineral wealth of the lower Susitna or make available the coals of the Matanuska fields. While this coal is probably barred for the present from tidewater competition with the Bering River coal, it yet has great value for local use. Moreover, and still more important, a railway to Fairbanks from Cordova will not serve the great Kuskokwim Valley and therefore not fulfill all the demands for rail connection with inland navigable waters. Fortunately, both the Kuskokwim and Susitna valleys can be developed by a railway from Seward to navigable waters on the Kuskokwim.

The building of this line into the Susitna valley is second in importance only to a line to Fairbanks, and its extension into the Kuskokwim should also be provided for as soon as possible, and the commission so recommends.

The commission believes that the two railway lines into which this discussion has resolved itself will form two systems that will at once advance development in the Territory. This recommendation for two trunk lines connecting navigable waters is in accord with the natural evolution of railway construction. In new countries the first lines of communication established are always those built over the main divides and connecting with navigable waters and thus serving to supplement water transportation. It is only in well-settled countries that lines tying together such transverse systems and paralleling waterways are built.

The industrial advancement which will follow the building of the main trunk lines can not fail to call for the extension of many branches to serve adjacent districts. There is no reason to believe that such branches will not follow in Alaska as they have in all railroad history, and such extensions will ultimately provide for intercommunication between the two systems here recommended. Several such extension lines have been mentioned in this report. Those most important, in the opinion of the commission, are the coal branches; the extensions from Fairbanks to the Yukon River, so that the scope of rail service may reach the main Yukon Valley; the extension from the Chitina-Fairbanks line to reach the Nabesna Valley; and one at least of the two routes connecting Valdez with the Copper River valley. In the opinion of the commission the two coal branches should be built at once; the others will follow the demand created by industrial development.

1. Chitina to Fairbanks, 313 miles	$13,971,000
2. Bering River coal branch via Lake Charlotte, 38 miles	2,054,000
3. Kern Creek to Susitna Valley, 115 miles	5,209,500
4. Matanuska coal branch, 38 miles	1,616,000
5. Susitna Valley to Kuskokwim, 229 miles	12,760,500

In conclusion it should be stated that the commission is unanimously of opinion that this development should be undertaken at once and prosecuted with vigor, and it can not be accomplished without providing the railroads herein recommended under some system which will insure low transportation charges and the consequent rapid settlement of this new land and the utilization of its great resources.

The board of road commissioners for Alaska [1] reports that since its organization and up to July 31, 1912, it has constructed 829 miles

[1] Richardson, W. P., Annual report of the board of road commissioners for Alaska for the season of 1912, p. 7.

of wagon road, 599 miles of winter sled roads, and 1,552 miles of trails. Among the most important projects undertaken in 1912 are a wagon road from Juneau to Sheep Creek and extensions of the Circle-Central House wagon road in the Yukon basin and of the Moose Pass road in Kenai Peninsula. The wagon road from Knik to Willow Creek was completed, as was also a sled road from Ruby, on Yukon River, to Long Creek. The importance of this work to the mining industry of the Territory can hardly be exaggerated. Any scheme for railway extension must be supplemented by the construction of wagon roads, if the needs of the Territory are to be well served.

There has been little change in steamboat service to and within Alaska during 1912. The most important river traffic is that of the Yukon and Tanana. It is reported that a direct steamboat service is to be established from Canadian Yukon ports to Fairbanks, which has been made a port of entry. Several steamers are run on the Kuskokwim, though with no great regularity of service. Susitna River is served only by launches, there being no large steamers on this river.

METAL MINING.

PRODUCTION.

In 1912 about 29 per cent of the total gold production came from lode mines, compared with 25 per cent in 1911. This indicates that lode mining is on the increase. It is expected that a very rapid increase in the percentage of lode output will take place in a few years, when the many lode enterprises already started will reach a productive stage. The output from placer mining will probably continue to decrease for several years until more large mining plants have been installed. In the following table, which is based in part on preliminary estimates, the production of precious metals has been distributed as to sources.

Sources of gold, silver, and copper in Alaska, 1912, by kinds of ores.

	Total.	Gold.		Silver.		Copper.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	*Ounces.*		*Ounces.*		*Pounds.*	
Siliceous ores	1,751,824	241,991.05	$5,002,399	35,696	$21,952	.....	.....
Copper ores	93,452	7,428.08	153,552	376,593	231,605	29,230,491	$4,823,031
Placers	.....	580,016.25	11,990,000	102,897	63,282	.....	.....
	1,845,276	829,435.08	17,145,951	515,186	316,839	29,230,491	4,823,031

In addition to the ores listed above, some tin is produced on Seward Peninsula (p. 50), but as most of this output is made by one

company, the figures, in accordance with the policy of the Survey, are not published. A small amount of lead is also recovered each year from Alaska ores. In the following table the production of gold, silver, and copper is given by years:

Production of gold, silver, and copper in Alaska, 1880–1912.

Year.	Gold.		Silver.		Copper.	
	Quantity.	Value.	Quantity.	Commercial value.	Quantity.	Value.
	Fine ounces.		*Fine ounces.*		*Pounds.*	
1880	967	$20,000			3,933	$826
1881	1,935	40,000				
1882	7,256	150,000				
1883	14,561	301,000	10,320	$11,146		
1884	9,723	201,000				
1885	14,512	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	1,038,000	8,400	6,570		
1894	62,017	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	9,160,000	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	936,044	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	780,131	16,126,749	157,850	85,239	4,241,689	538,695
1911	815,276	16,853,256	460,231	243,923	27,267,878	3,408,485
1912	829,435	17,145,951	515,186	316,839	29,230,491	4,823,031
	10,292,541	212,765,727	3,094,048	1,841,203	90,294,477	13,570,225

The total production of gold in Alaska is in the following table distributed according to districts. No systematic collection of statistics of Alaskan gold production was made previous to the year 1905. Therefore the figures presented in this table for the years preceding 1905 are probably in considerable error—possibly as much as 15 per cent. It should be noted that, as complete statistical returns are not even yet available, owing to the fact that some producers do not furnish information of output, the other figures in this table are also not entirely correct. The error of distribution is believed to be less than 3 per cent. This error will not be entirely eliminated until the complete cooperation of all mine operators is secured.

The production from the Pacific coast belt is derived principally from the lode mines of southeastern Alaska but includes also the output of a gold-lode mine on Unga Island and of several gold and copper lode mines on Prince William Sound, as well as a small output from gold placers. Previous to 1885 the placers of the Juneau district

yielded considerable gold, and since 1899 the Porcupine district of southeastern Alaska has been a small but steady producer. The beach placers along the Pacific seaboard have been worked each year on a small scale since about 1890.

Up to 1909 all the gold produced in the Copper River and Cook Inlet region was obtained from placers. Since then several small lode mines on Kenai Peninsula and in the Willow Creek district have been productive. Much the larger part of the gold produced in the Yukon basin and Seward Peninsula has been derived from placers. In the last three years there have been a number of productive lode mines in the Fairbanks district (see pp. 137–202), and since 1903 a little lode gold mining has been undertaken at different times in Seward Peninsula.

Value of gold production of Alaska, with approximate distribution, 1880–1912.

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	838,000		200,000		1,038,000
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	3,195,400	500,000	1,300,000	4,164,600	9,160,000
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	22,036,794
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	4,182,730	351,630	[a]8,062,389	3,530,000	16,126,749
1911	4,265,573	313,538	[a]9,139,145	3,135,000	16,853,256
1912	4,904,753	358,401	[a]8,857,797	3,025,000	17,145,951
	61,382,627	5,032,069	82,976,331	63,374,700	212,765,727

[a] Includes a small production from the Kuskokwim basin.

The output of the Yukon basin given in the above table includes, of course, only that of the Alaska camps. Gold to the value of $4,000,000 or $5,000,000 is annually produced from the Klondike and other smaller Canadian Yukon districts. Since 1910 there has been a small annual gold output from the lower Kuskokwim basin, and in the above table this is included in the output of the Yukon basin.

METALLIFEROUS LODES.

STATISTICS.

The total gold production from the auriferous lode mines of Alaska which have been productive since 1882 is estimated to be 27,966,622 fine ounces, valued at $57,811,300. These mines have also produced 1,065,439 fine ounces of silver, with a commercial value of $648,853. The total copper production up to the close of 1912 was 90,293,397 pounds, valued at $13,570,225. Tin mining began in the York region, Alaska, in 1902. During the last two years, owing to the installation of a dredge, the mining of placer tin has been systematically prosecuted. Up to the close of 1911 tin to a total value of $244,451 has been produced. From 50 to 60 tons of lead is annually recovered from Alaska ores.

Alaska's auriferous lodes are estimated to have produced during the year 241,991 fine ounces of gold, valued at $5,002,399, compared with an output of 204,466 ounces, valued at $4,226,687, in 1911. Most of this increase is to be credited to the Juneau district, yet there was relatively a considerable increase of output in most of the other gold lode districts.

Twenty-four gold lode mines, including several properties in the new lode districts, which made only small outputs, were operated the whole or a part of the year in Alaska in 1912—five more than in 1911. Of the producing mines, seven were in southeastern Alaska. Work was also done on many gold prospects, a few of which produced some gold as an incident to the development work.

It is estimated that these mines had an output of 1,751,824 tons of ore, compared with 1,594,404 tons in 1911. In 1911 the average value of gold and silver contents for all the ores mined was $2.66 a ton; the average in 1912 is estimated to have been $2.93.

There were eight productive copper mines in 1912, the same number as in 1911. Of these, three were in the Ketchikan district, four on Prince William Sound, and one in the Kotsina-Chitina district. In addition to the output of the eight productive mines, there were some small shipments of copper ore from several properties that are being developed. The total copper production in 1912 was 29,230,431 pounds, valued at $4,823,031, compared with 27,267,878 pounds, valued at $3,408,485, in 1911. About $153,552 worth of gold and $231,605 worth of silver was recovered from the copper ores. It is estimated that in 1912 about 93,452 short tons of copper ore were hoisted, compared with 68,975 tons in 1911. The average copper content of the ore was about 15.64 per cent and the value of the gold and silver about $4.11 to the ton. The large average copper percentage is due to the very high grade ores shipped from the Bonanza-Kennicott mine.

SOUTHEASTERN ALASKA.

GENERAL CONDITIONS.

The seven auriferous lode mines operated in southeastern Alaska in 1912 produced gold to the value of $4,418,392, compared with an output of $3,904,217 from eight mines in 1911. A much larger annual gold output is to be expected within a few years, when several large enterprises now under way reach a productive stage. No great progress was made in developing copper properties in southeastern Alaska. Sufficient work was done at several mines to indicate that they may soon become shippers.

The following notes on mining development are believed to cover the most important events of the year. As, however, no geologist visited the region, it is impossible to present a complete record of all the mining activity. The information here set forth is largely taken from the schedules returned by the lode-mine operators and owners. Unfortunately, many of those interested in nonproducing properties fail to return the schedules. The writer desires to call attention to the fact that the schedules are of great value as a record of mine and prospect development of the nonproductive as well as of the productive properties. In the interest of the mining industry all connected with the development of the properties are urged to furnish a statement of their operations to the Geological Survey promptly each year.

JUNEAU PRECINCT.

Though only five gold mines were producing in the Juneau precinct during 1912, the activity in development work was so great as to augur well for the future gold output. The Treadwell group of mines continues to overshadow all other enterprises, but several other properties are being developed on a large scale.

The Treadwell companies completed the installation of the first unit of a hydroelectric plant on Nugget Creek, with an ultimate capacity of 3,000 kilowatts. The central hoisting and crushing plant was practically completed. Changes were also made in pumps and minor machinery from steam to electric power. As usual, the mines of the Treadwell group were operated throughout the year. At the Treadwell mine the ore was taken chiefly from the 750, 1,250, 1,450, and 1,600 foot levels, while dead work was done on the 1,750-foot level. The ore mined at the Alaska-Mexican was taken from the 1,100, 1,210, 1,320, and 1,460 foot levels, and considerable dead work was accomplished on the 1,460 and 1,570 foot levels. At the Ready Bullion the ore was taken chiefly from the 1,500-foot level and much work was done on the 2,000-foot level. At the Seven Hundred Foot claim ore was taken from the 990, 1,100, 1,210, and

1,320 foot levels, and drifts were also advanced on the 1,570, 1,600, and 1,750 foot levels.

The mill of the Perseverance mine, the property of the Alaska-Gastineau Co., was operated, as in the past, from May to October. This 100-stamp mill and crushing plant was completely destroyed by fire December 4, 1912. The underground operations consisted in enlarging and retimbering the main adit, drifts, and shaft and driving about 500 feet of drift. These operations were undertaken preparatory to connecting the mine workings with a working and transportation tunnel which is being driven from the Sheep Creek side of the divide and about 2,500 feet of which had been completed at the close of 1912. This tunnel will be 8,000 to 9,000 feet in length and will be about 650 feet below the main level of the Perseverance mine. It is to develop not only the Perseverance mine but also the Silver Queen and other properties lying on the Sheep Creek side of the divide. Construction has been started on a milling plant near the mouth of Sheep Creek, to have a capacity of 6,000 tons a day. A hydroelectric plant is to be installed on Salmon Creek.

The 30 stamps of the Alaska-Juneau mine were operated from May to October and were supplied with ore from open cuts. The heading of the new adit tunnel being driven from Gold Creek was advanced to 4,383 feet by the close of the year but is still about 1,700 feet from the ore body. It will undercut the ore body of the Alaska-Juneau about 600 feet below the old workings. The ore is to be trammed from the portal of the adit to a mill which will be erected near tidewater.

The California-Nevada Copper Co., which owns the Ebner mine, on Gold Creek, went into a receivership and a new company, called the Alaska-Ebner, is said to have been organized to take over the property. Some work was also done on the Salmon Creek side of the divide, on what is believed to be a northwesterly extension of the mineralized zone opened by this mine.

At the Petersen property, near Pearl Harbor, north of Juneau, the developments in 1912 consisted of an inclined shaft sunk 50 feet, together with some open cuts. The driving of the new lower adit near the stamp mill was continued at the Eagle River mine. While some work was undoubtedly done at other properties in the region lying between Juneau and Berners Bay, the writer has no information in regard to it.

It is reported that the driving of the adit on the main level of the Kensington mine, at Berners Bay, was continued during 1912. Development work was also continued at the Jualin mine, in the same district. A large air compressor was being installed at the close of the year.

The writer has little information about developments south of Juneau. It is reported that a 100-foot tunnel and a 40-foot upraise were completed on the Daisy Bell claim, near Snettisham, and that this work revealed a 4-foot body of ore. Some work was also done on a group of claims located near the point at the junction of Gastineau Channel and Taku Inlet.

KETCHIKAN PRECINCT.

No noteworthy advances were made in the Ketchikan precinct in 1912. Only three copper mines were producing. Two gold mines, which are equipped with stamps, were also operated, and some gold was probably produced, but of this there is no definite information at this writing. The high price of copper has stimulated the development of copper deposits, and as a result considerable advance was made on several properties. The Jumbo mine was operated throughout the year. On this property 136 feet of shaft was sunk during the year and the aggregate of drifting amounted to 450 feet.

The Rush & Brown mine continued productive operations throughout the year. The shaft was sunk to a depth of 184 feet and drifting was continued on the first and second levels, from which the ore was stoped. Some work consisting of drifts and crosscuts, was done at the Copper Mountain mine, which has long been idle. Some developments were also made at the Red Wing mine. Work was continued on the long adit of the It mine, from which some shipments were made. So far as learned, the Mount Andrew mine was idle for most of the year, though plans were made to put it again on a productive basis. Some work was also done on the Victory and Sanford groups of copper claims, near Seal Bay. It is reported that the Northland Development Co. has done considerable underground work on a copper property located on "Big Harbor."[1]

Work was continued on the main level of the Lon de Van property, on George Inlet. A crosscut was completed in January, 1912, encountering the ore body 2,064 feet from the portal and about 900 feet below the outcrop of the vein. Since then the ore has been followed some 1,600 feet by drifting. The ore is said to contain silver, lead, gold, copper, and zinc.

The Princeton Mining & Milling Co. continued work on its property near Dolomi. A 100-horsepower boiler and air compressors were installed. In the fall of 1912 a 10-stamp mill was erected. Late in the year the Goldstream mine, on Gravina Island, was again opened, and the 5-stamp mill is said to have been operated. Developments were said to have been resumed in 1912 on the Moonshine silver-lead

[1] The location of "Big Harbor" is not known to the writer, but it is probably one of the indentations of Dall Island, in the western part of the Ketchikan district.

property, which is located on Cholmondeley Sound. Work was continued on the Martin-Bugge properties, near Smugglers Cove, on the mainland north of Ketchikan. The developments in 1912 consisted of drifting on the vein on both sides of the adit and in increasing the surface equipment.

SITKA AND OTHER PRECINCTS.

The Chichagof and Golden Gate mines were combined under one management in 1912. The former was operated for the entire year; the latter for the last nine months of the year. A total of 300 feet of sinking, 160 feet of raising, and 2,800 feet of horizontal work was done in these two mines during 1912. It is reported that a discovery of rich gold ore was made by Bernard Hirst in 1912 near the Chichagof mine.

During 1912 nothing of importance occurred in lode development in the Porcupine, Skagway, and Wrangell districts. There was, however, considerable lode prospecting in the Wrangell and Porcupine districts. Mention of the gold placers of the Porcupine district will be found on page 43.

PRINCE WILLIAM SOUND.

GENERAL FEATURES.

Much advance was made in developing the mineral resources of Prince William Sound during 1912. Three copper mines made regular shipments of ore, and smaller shipments were made from several other properties that are under development. While only one gold mine was productive, in the aggregate considerable ore was recovered from other properties incidentally to mining operations. It is estimated that the mineral production of Prince William Sound in 1912 had a value of $1,250,000, compared with $1,000,000 for 1911.

PRINCIPAL COPPER MINES.

The most important localities of copper production were the region tributary to Ellamar and Landlocked Bay, described on pages 86–124, and Latouche Island. The Beatson-Bonanza mine on Latouche Island was operated throughout the year, though in December operations were somewhat hampered by the destruction of the electric power plant by fire.

The Knights Island Copper Co. employed a force of men in September and October in driving a 50-foot drift. Development work is reported on three properties located near Fidalgo Bay, namely, those of the Fidalgo-Alaska Copper Co., the Fidalgo Mining Co., and Mason & Gleason. The Fidalgo Mining Co. is the only one of these companies which has made report to this office. On this property some 600 feet of underground work has been done, and an aerial tram is being installed.

PORT VALDEZ DISTRICT.

The Cliff gold mine was operated throughout the year. In October the mine workings had been extended to the fifth level, and it is currently reported that the vein and its tenor had been found to persist to this depth. At the Gold Bluff, located not far from the Cliff mine, about 240 feet of underground work was done in 1912. Some developments are also said to have been made at the Bluff and on the Sealy-Davis properties. A new company is said to have taken over the Bluebird mining claim, west of Shoup Bay, and to have started systematic development.

Much work was done on the Alice claim, on Shoup Bay. An air compressor and pump were installed, and a two-compartment shaft sunk to a depth of more than 100 feet. The Thompson & Ford property, about 2 miles from Shoup Bay, is said to have been developed by a 400-foot adit tunnel and two crosscuts. At the Owl property, which is close at hand, the developments are reported to consist of 230 feet of adit tunnel. Some work was done during the year on a number of other claims in this part of the district.

Of the properties in the Columbia Glacier region the Mayfield, 9 miles from Shoup Bay, is the most extensively developed. This property has been developed by adit tunnels on two levels, aggregating 500 feet in length. The Cameron-Johnson property, in the same general district, has 267 feet of adit. Some shipments were made from this property, the ore being hauled to tidewater at Shoup Bay.

In the Mineral Creek district developments were continued on the Hercules, Millionaire, and other properties. Important discoveries of ore are reported to have been made at the Ramsay & Rutherford group of claims, on the east side of Valdez Glacier. Two intersecting auriferous quartz veins, having widths of 1 to 7 feet, are said to occur on this property. In 1912 a crosscut was driven, which intersected the larger vein at a depth of about 45 feet, and the ore body was then followed by drifting for some 90 feet. A winze has been sunk about 40 feet below this level and 90 feet below the surface, and from the bottom of this a crosscut was carried to the vein, which showed a width of 2 feet or more. An air compressor and a hoist have been installed at this mine and preparations have been made for continuing work.

Besides those above chronicled, other mining developments have taken place in the Port Valdez district and adjacent country. Some auriferous veins have been found in the region tributary to the military road extending inland from Valdez. Valuable discoveries are reported to have been made in the Tiekel region and also in the Tasnuna Valley, not far from Marshall Pass. The evidence in hand indicates that mineralization has been widespread in the Port Valdez

district and adjacent regions and that there is therefore good hope of finding other workable deposits than those thus far discovered.

The Midas copper property, on Solomon Gulch, a tributary to Port Valdez from the south, was taken over by a new company in 1912 and systematically developed, and some ore was shipped. Some 300 feet of tunnel, three crosscuts, and upraises aggregating 100 feet have been completed. Preparations have been made to continue work on a large scale. This is the only copper property that has been developed in the Port Valdez district, though a little copper ore is reported from other localities.

PORT WELLS DISTRICT.

No geologic examination of the Port Wells region has been made since Grant and Higgins's reconnaissance in 1905. According to their report[1] the bedrock of the region consists of slates and graywackes, with some areas of intrusive granite and, in certain localities, many small dikes of light-colored igneous rock. At the time of their visit to this district no mineral deposits of importance had been discovered. The mining developments in the Valdez district stimulated the search for gold deposits in the Port Wells district, for the prospector correctly reasoned that, the geologic conditions being similar, the chances were good for finding workable ore bodies. Several promising discoveries are reported to have been made in this field in 1911 and others in 1912.

According to the best information available the gold veins thus far found are located chiefly along the two shores of Port Wells, though some have been found on Harriman Fiord and some on the peninsula separating Port Wells from Unakwik Inlet, to the east. As in all new camps, prospecting and therefore discoveries have been confined chiefly to the region close to tidewater. A small settlement known as Port Wells, including one or two stores, is located near the point which marks the southeast shore of the strait connecting Port Wells and College Fiord. Although a post office, this place had no regular mail service; communication is kept up with Cordova and Valdez by gasoline launches that make occasional trips under charter.

The veins of the district, according to Mr. Stephen Roe, to whom the writer is indebted for information, generally trend about northeast and southwest and cut across the country rock. It is stated that the ores carry free gold, auriferous pyrite, silver-bearing galena, and, in some places, chalcopyrite. The gangue is quartz with some calcite. Though but little underground work has been done, some of the veins are said to have been traced a thousand feet or more. The veins are said to have good walls, in many places with a gouge.

[1] Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: U. S. Geol. Survey Bull. 443, 1910.

In the absence of an official examination, it is perhaps not safe to publish second-hand information on the width of the veins. It will suffice to state that experienced prospectors who have visited the district say that the ore bodies are large enough to assure profitable exploitation if they are found to persist at depth and hold their tenor. No large ore bodies have been reported, however, though many small ones said to carry much gold have been found.

Near Port Wells settlement the Golden vein is said to have been followed by a 30-foot drift which undercut the outcrop about 25 feet. At the Gold Wonder some 60 feet of work is reported, and at the Nugget property, said to be on same vein, 150 feet of underground work was done. Adjacent is the Consolidated property, developed by a 45-foot shaft. It appears that the Herman-Everman property, on Bettles Bay, an indentation of the west side of Port Wells, is the most extensively developed in the district. Here a shaft more than 70 feet deep was put down in 1912, and sinking was being continued at the close of the year, with the plan of reaching a depth of 100 feet and then driving on the vein. Some work has also been done on the Singletary-O'Neil property, on Harriman Fiord. Gold-bearing veins are also reported to have been found on College Fiord, on Esther Island, and on the mainland near the lower end of Esther Passage.

KENAI PENINSULA.

While no lode properties were developed on a large scale in the Kenai Peninsula during 1912, yet in the aggregate considerable work was accomplished. Details in regard to some of the mining activity are lacking, but the following data, in part based on notes furnished by B. L. Johnson, are believed to cover most of the important developments during the year. Three small stamp mills were operated by the Kenai-Alaska, Primrose, and Skeena-Lechner mining companies for a part of the summer season. Some gold was also recovered by means of arrastres, but the total production of lode gold in 1912 was less than $20,000 in value. The dead work accomplished was considerable in spite of the fact that, as indicated above, but few of the mines were productive.

Some work was done on an auriferous quartz vein located on the beach about half a mile from Seward and also on a mineralized zone about a mile from the 4-mile post on the Alaska Northern Railroad.

The so-called Mile Seven property, including the Homestake and Bear groups of claims, located on Lost Creek near Seward, was staked in 1911, and prospecting was begun in the fall of that year. It is reported that up to the close of 1912 some 450 feet of underground work had been done, besides considerable open-cut work. The owners considered the ore bodies revealed by these operations

to justify the installation of a 2-stamp prospecting mill, which began operation in January, 1913.

In 1912 a 3-ton mill was erected and operated for a part of the season on the Primrose property, on Porcupine Creek, which is tributary to Kenai Lake. This deposit is apparently in the same mineralized belt as the one on Lost Creek. It is said to be developed by a shaft 45 feet in depth and 350 feet of adits and drifts.

An aerial tram was installed on the property of the Kenai-Alaska Gold Co., on Falls Creek. Underground developments were continued in 1912, including 80 feet of drifts and a 50-foot winze. The stamp mill was operated for about six weeks.

Work was also continued on the Skeena-Lechner property, in the same district. Some ore from this mine was milled at the small plant of the California-Alaska Co. near by. Considerable underground work was done at the Skeena-Lechner mine, the details of which are lacking at this writing. At the Hickey property, near mile 21, the adit tunnel was extended to a length of about 200 feet in 1912.

It is reported that considerable work was done in 1912 on the Bluebell quartz claim, located on Porcupine Creek. Late in the fall a small stamp mill was in process of installation on this property. Some work was done on the Independence quartz claim, where ore was treated in an arrastre. A small mill was put on the Imhoff property, in the southern part of the Moose Pass district. In the aggregate considerable prospecting was done on other properties in the Moose Pass district, but no important single developments are reported. A 50-foot shaft was seen on the Kenai Star quartz prospect, on Palmer Creek, in the Hope region. Some work was done in 1912 on the Conway prospect, west of Bird Point, on Turnagain Arm, from which a test shipment of 2 tons of ore was made.

SOUTHWESTERN ALASKA.

As in previous years, the Apollo mine, on Unga Island, was in 1912 the only productive lode property in southwestern Alaska. Prospecting, however, was continued at several other localities, notably in the Iliamna region. A preliminary report on the mineral resources of Kodiak Island is presented elsewhere in this volume (pp. 125–136).

The writer is indebted to Mr. Thomas W. Hanmore, United States commissioner at Iliamna, for the following notes on mining in the adjacent region. He reports that William Duryea has driven two adit tunnels on his property,[1] located on Silver Creek, near Iliamna Lake. One of these is said to have cut galena ore at a depth of 150 feet, and the other a body of arsenopyrite ore, as well as a zinc-lead

[1] Martin, G. C., and Katz, F. J., A geologic reconnaissance of the Iliamna region, Alaska: U. S. Geol. Survey Bull. 485, pp. 124–125, 1912.

ore deposit. Considerable development work was done by Pete Morris on a group of claims located near Kontrashibuna Lake.[1] Further prospecting by diamond drills is planned. E. E. Taylor drove a 40-foot adit tunnel on a copper-bearing lode, known as the Knudsen claim, located not far from the north shore of Iliamna Lake.[2] Further discoveries of copper-bearing ore are said to have been made on the Millet claims,[3] located in the same general district. New discoveries of silver-lead ores are said to have been made by William Gleason on Kijak River, near Lake Clark. It is also reported that C. H. McNeil and Norman B. Cook have found some copper-bearing veins on Okchiak Creek, a tributary to a southwest bight of Kamishak Bay.

WILLOW CREEK DISTRICT.

Three quartz mines—the Gold Bullion, Alaska Free Gold, and Gold Quartz—were operated in the Willow Creek district in 1912. Each of these properties is equipped with a small mill which operated during the summer season, crushing in all about 3,000 tons of ore and producing gold to the value of about $100,000. The properties have thus far been operated only on a small scale, chiefly owing to the high cost of transportation. Therefore, perhaps the most important event of the year was the completion of a wagon road up the Little Susitna, rendering the eastern part of the district accessible. Plans are now being made looking to larger developments by continuing certain properties and developing hydroelectric power on the Little Susitna. Several discoveries of gold-bearing quartz are said to have been made in 1912, notably one by A. C. Shough, reported to be a quartz vein carrying a large amount of gold, located on the east side of the upper Little Susitna basin.

Two discoveries of metalliferous lodes that may prove important are reported to have been made in the region tributary to the Willow Creek district. One of these is an occurrence of copper ore (bornite) on the south side of Sheep Mountain, in the upper Matanuska basin. According to Paige and Knopf[4] Sheep Mountain is made up of andesitic greenstones and other volcanic rocks, with at least one intrusive mass of granitic rocks. While there had been no lode prospecting in this field at the time of their investigation (1906), yet they noted evidence at Sheep Mountain of pyritiferous mineralization, and a sample collected by them showed a trace of gold. The geologic evidence in hand indicates that the locality is well worth further prospecting.

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[1] Martin, G. C., and Katz, F. J., A geologic reconnaissance of the Iliamna region, Alaska: U. S. Geol. Survey Bull. 485, p. 122, 1912.

[2] Idem, pp. 122–123.

[3] Idem, p. 22.

[4] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, pp. 23 and 65, 1907.

The writer is indebted to Mr. H. H. Sharp, of Knik, for information about some lode prospects located on Peters Creek, a tributary from the southeast to Knik Arm. These occurrences are about 20 miles from tidewater. The bedrock is said to be slate and graywacke, with some intrusives. As described, the mineral occurrences consist of auriferous stringers and veins in a mineralized zone which trends northeastward. Some of the veins are said to have been traced by means of stripping for 300 to 400 feet.

NABESNA–WHITE RIVER REGION.

The advances made in developing the metalliferous lodes in the Kotsina-Chitina copper belt, on the south side of the Wrangell Mountains, have in a measure reawakened interest in the Nabesna-White River copper belt, north of the Wrangell Mountains. Productive lode mining in this field is dependent on railway connection with tidewater, but meanwhile there is reported to be considerable prospecting, about 25 prospectors being in the field. Supplies are now brought in chiefly by boat up White River. Another route of approach, also frequently used, is over the Skolai Pass from the inland terminal of the Copper River Railroad. Both copper and gold bearing lodes are being prospected in this field. The deposits are in part on the Canadian side of the international boundary. A group of copper claims, said to be owned by the Northern Commercial Co. and located on the Middle Fork of White River, were surveyed for patent in 1912. Coal is reported to occur on the Canadian side of the White River basin.

YUKON BASIN.

The advances in lode-mining development in the Yukon basin during 1912 were practically confined to the Fairbanks district. Lode mining at Fairbanks is described in a separate chapter of this volume (pp. 137–202). There was also a small lode mine in operation in the Innoko district (see p. 298), and a little work was done on lode prospects in the Chandalar, Fortymile, and other Yukon districts. Most of these localities of lode occurrence are so isolated that the cost of operation is almost prohibitive. It is only by reducing transportation costs by building railroads and wagon roads that any advances in the lode-mining industry of inland Alaska can be brought about.

SEWARD PENINSULA.

There is little information at this writing in regard to lode mining in Seward Peninsula during 1912. It is reported that work was continued on a number of prospects located chiefly in the Nome dis-

trict. Ore from some of these was treated at the Nome customs mill. The New Era Mining Co. installed a small prospecting mill at Snow Gulch to test an auriferous lode. Some work was also done on the Consolidated group of claims near Topkok. There were undoubtedly other developments of equal importance, but they have not been reported to the writer.

GOLD PLACERS.

GENERAL FEATURES.

It is estimated that since mining began in Alaska in 1880 the gold placers of the Territory have yielded 7,488,491 fine ounces of gold, valued at $154,800,875. These mines have also produced 1,652,016 fine ounces of silver, with a commercial value of $960,743.

The gold placer mines of Alaska are estimated to have produced in 1912 gold to the value of $11,990,000, compared with an output in 1911 valued at $12,540,000. This decrease is due to a general falling off in nearly all the placer camps. The gold output of Fairbanks, Hot Springs, Seward Peninsula, and several of the less important districts was less in 1912 than in 1911, while the output of the Iditarod-Innoko region and of the Koyukuk district alone showed any marked increase compared with previous years. It is not to be expected that under present industrial conditions there will be any stability of placer-gold output in the Territory. So long as the high cost of transportation prevails, the production of placer gold must depend on the exploitation of bonanza deposits, for these alone can be expected to yield profitable returns. Relatively little progress has been made in undertaking the mining of the extensive bodies of auriferous gravels carrying a low gold tenor except in Seward Peninsula, where the installation of dredges has continued.

It is estimated that a total of about 720 placer mines were operated in 1912, compared with 740 in 1911. It is also estimated that about 150 placer mines were operated in the winter, employing 900 men, and about 600 during the summer, employing about 4,500 men. In addition to these, from 1,000 to 1,500 men were engaged in prospecting and other nonproductive work relating to placer mining.

In accordance with past practice, a table is given here to show approximately the total bulk of gravel mined annually in Alaska for several years and the value of the gold recovered per cubic yard. This table is based on certain assumptions which do not now admit of proof but which are supported by the available facts. Therefore, although the table is only approximate, it probably indicates something of the magnitude of the true figures.

Estimated total amount of gravel sluiced in Alaska placer mines and value per cubic yard of gold recovered, 1908–1912.

Year.	Total quantity of gravel (cubic yards).	Value of gold recovered per cubic yard.
1908	4,725,000	$3.74
1909	4,418,000	3.66
1910	4,036,000	2.97
1911	5,790,000	2.17
1912	5,700,000	2.10

The progressive reduction in the gold tenor of the gravels mined is the most hopeful feature of Alaskan placer mining, because it indicates a lessening of cost of operation. The decrease of average gold tenor in 1912, compared with the previous year, is due largely to the increased use of gold dredges, notably in Seward Peninsula. Hydraulic mining is also on the increase and will undoubtedly play a more important part in the placer-mining industry of Alaska than it has in the past. It is to be noted, however, in this connection that in a large proportion of the Alaska placer districts water supply, stream gradients, and other essential conditions are unfavorable to hydraulic mining. Under these circumstances future improvement in mining methods must be in the direction of using mechanical equipment, such as dredges and drag-line excavators. In spite of the reduction in the output of placer gold in Alaska, there can be no question that a large field for profitable mining ventures would be opened by decreasing operating costs through improvement of transportation facilities.

Thirty-eight dredges were operated in Alaska in 1912, compared with 27 in 1911. In addition to these, a dozen or more were in various stages of construction. It is estimated that these dredges handled between 3,200,000 and 3,600,000 cubic yards of material. Gold to the value of about $2,200,000 was recovered by dredging. Of these dredges, one was in Kenai Peninsula, three in the Fortymile district, one in the Fairbanks district, one in the Birch Creek district, and the rest in Seward Peninsula.

PACIFIC COAST REGION.

For the purposes of this discussion the Pacific coast region will be defined as covering 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 1912 an output valued at $320,000, which was practically the same as the value of the output in 1911.

Southeastern Alaska.—One mine operating near Juneau and two or three in the Porcupine district continue to be the only placer mines

in southeastern Alaska. It is reported that some investigations of auriferous gravels on Montana Creek, near Juneau, were made with a view to the installation of a dredge. A hydraulic plant was operated on Porcupine Creek and another on Calhoun Creek during the open season of 1912. Some work was also done on other creeks of the district, notably on Glacier Creek, where preparations were made to install a hydraulic plant.

Beach mining.—About 15 or 20 men were engaged in beach mining in the Yakataga district. The hydraulic plant on White River, in this district, was not operated in 1912, work on this property being concentrated on extending the ditch line. The beach placers of Kodiak Island are described elsewhere in this volume (pp. 134–136). Some beach mining was done on Popof Island, as in previous years.

The writer is indebted to Mr. Stephen Roe, of Port Wells, for some notes on the occurrence of beach placers on Middleton Island. There appears to have been no beach mining done on this island for several years, but it seems desirable to put in the permanent record some account of these deposits. Middleton Island is located in the Gulf of Alaska about 50 miles south of the entrance to Prince William Sound. A flat-topped upland, whose surface stands about 120 feet above the sea,[1] occupies most of the island. The surface of the upland is somewhat pitted, some of the depressions being occupied by lakes. In most places the upland falls off to the beach by an escarpment, which contains partly consolidated gravels with some bowlders, apparently of glacial origin. In places hard rock is exposed in the escarpment.

The gold placers that have been worked occur at the southwest end of the island. They are beach placers at the foot of bluffs, in material which has been subject to wave action. Garnet is found in association with the placer gold. Most of the gold is flat, and typically it occurs only in small grains. Some small nuggets, the largest of which had a value of 83 cents, have been found. The first mining on the island, so far as known, was done in 1901, and gold to the value of about $8,000 has been recovered from these placers.

Copper River region.—Mining operations in the Nizina district are described on pages 84–85 of this report. There was also in 1912 a little placer mining in the Bremner district, of the lower Copper River region. It is estimated that seven placer mines were operated in the Chistochina district (Chisna) in 1912, employing about 45 men, and that the value of the output was probably less than in 1911. The conditions were unfavorable because of the lateness of the spring breakup. Prospecting with churn drill was continued on Chisna River. Preparations were also made to undertake a large placer-mining enterprise on Slate Creek.

[1] Alaska Coast Pilot, Notes from Yakutat Bay to Cook Inlet and Shelikof Strait (2d ed.), Coast and Geodetic Survey, 1910.

Kenai Peninsula.—Mining continued on Kenai Peninsula on about the same scale as in previous years. About 20 to 25 mines were operated, of which 8 or 10 were hydraulic mines. The largest of the hydraulic mines is located on Crow Creek, north of Turnagain Arm, and is not on Kenai Peninsula proper, though it is in the same general district. One dredge was operated on Kenai River, and considerable prospective dredging ground on another property was tested with a churn drill.

Susitna basin.—The Yentna district, described below, is the most important placer camp of the Susitna basin. In 1912 a little placer mining was done also on Willow Creek and on Caribou Creek, tributary to the upper Matanuska. A few small plants were operated on Valdez Creek, which lies in the headwater region of Susitna River. A number of claims that have been worked on Valdez Creek in previous years were idle in 1912 pending the launching of a larger mining enterprise.

The season of 1912 was a prosperous one in the Yentna district. Water was abundant—in fact, at times some of the streams were so flooded as to interfere with mining operations. It is estimated that about 100 men were engaged in mining. The most important operations were on Thunder, Dollar, Nugget, Willow, and several other tributaries of Cache and Peters creeks. Plans have been made for installing a hydraulic plant on Thunder Creek. Some placers occuring in elevated gravels on Dollar Creek were developed, it is reported, with good results. Some mining was also done on Twin Mills and other creeks of the west end of the Yentna district.

Iliamna region.—According to Thomas W. Hanmore, a little mining was done in the Mulchatna basin and in some streams tributary to Lake Clark, all in the Iliamna region. A little coarse gold was taken from the placers of Portage Creek, which flows into Lake Clark from the west. In the Mulchatna region the prospectors directed their attention to the benches, and encouraging results are reported from Bonanza and Ptarmigan creeks.

YUKON BASIN.

GENERAL STATEMENT.

It is estimated that the value of the gold produced in the Alaska portion of the Yukon basin was $8,645,000 in 1912, compared with $9,050,000 in 1911. This decrease is due to the falling off of the output from the Fairbanks and Hot Springs districts, for the other Yukon camps either held their own or somewhat increased their output compared with the preceding year. Probably the most encouraging feature of the year's activity was the definite proof of the presence of workable placers in the Ruby district. (See pp. 279–292.)

The Fairbanks district continued in 1912 to be the largest producer of placer gold of the Yukon. It can not maintain this position long without a radical change in mining conditions which will make it possible to exploit profitably its extensive bodies of low-grade placers. But little has been accomplished in this direction, and the best hope of the future lies in obtaining direct railway connection with tidewater. Accounts of the mining progress during the year in the Yukon-Tanana region are presented on pages 203–222 of this report, and in the Ruby, Innoko, and Iditarod districts on pages 279–303. It remains here, therefore, to consider only the mining in some of the more isolated camps that were not visited by any member of the Survey in 1912. The data presented were obtained from what are believed to be reliable sources.

Bonnifield and Kantishna districts.—The Bonnifield and Kantishna districts are remote camps in which mining costs are excessive. So far as learned, placer mining was continued in these districts on about the same scale as in previous years. About 50 or 60 men were engaged in mining in these two districts, and the gold output in 1912 is estimated to have a value of about $50,000, which is approximately the same as that of 1911. Several men who were formerly engaged in placer mining in the Kantishna district have turned their attention to prospecting auriferous lodes. A fact bearing on a possible easterly extension of the placer gold of the Bonnifield district has recently come to the writer's notice. This is to the effect that several years ago a little placer gold was mined on McCumber Creek, a tributary of Jarvis Creek. Jarvis Creek flows into the lower Delta River from the southeast. This evidence and other facts known about the geology suggest that the gold-bearing rocks of the Bonnifield district may extend into the unsurveyed region lying south of the Tanana and east of the Delta.

Koyukuk and Chandalar districts.—Only one or two placer mines were operated in the Chandalar district during 1912, and these in only a very small way. On the other hand, the Koyukuk district had an exceedingly prosperous season. It is estimated that more than 400 men were employed in the Koyukuk district during the mining season. It is reported that some very rich placer ground was found on Hammond River by sinking to a depth of 60 to 120 feet. Some successful prospecting with churn drill is said to have been done in this field. The gold found is chiefly very coarse, one nugget worth $280 being reported. Work continued in 1912 on Emma, Smith, Swift, Nolan, Minnie, and other creeks previously developed, but details in regard to these operations are lacking. Mining was also continued in the Indian River region, in the southwestern part of the Koyukuk district.

KUSKOKWIM BASIN.

Much of the Kuskokwim basin is still but little known. Although prospectors have roamed over most of it, little thorough prospecting has been done except in those streams which head in the Innoko divide. A small amount of placer gold has been found in the headwater region of the Kuskokwim, but no mines have been developed. The mining in that part of the Kuskokwim lying near the Iditarod-Innoko district is described elsewhere in this report (pp. 299–303).

During the last few years there has been considerable prospecting of the region tributary to the lower Kuskokwim, between the Iditarod district and Bering Sea. The information at hand indicates that the geologic conditions in this region are similar to those in the Iditarod. Auriferous gravels have been found at many places in the region, but so far as has been learned no very rich deposits have been disclosed. Placer mining on a small scale has, however, been carried on, notably in the Anniak River, Tuluksak River, and Goodnews Bay regions. The value of the total gold production to date is estimated to be between $75,000 and $100,000. In 1912 there were probably some 200 men in this general field, most of whom were engaged in prospecting rather than in productive mining. So far as can be learned (for the district has not been examined by a geologist), considerable low-grade placer ground has been found which would not yield profitable returns under present costs and methods of mining. Some richer gravels that have yielded returns to the ordinary manual methods of operation have also been found. Plans have been formulated for the installation of dredges and hydraulic plants with the purpose of exploiting some of the gravels of lesser gold tenor. This region presents no greater difficulties of transportation than other inland districts of Alaska which have been profitably exploited. Ocean vessels can enter Kuskokwim River and transfer their freight direct to river steamers. The placers, however, are 30 to 60 miles from the limits of steamboat navigation, and in the absence of wagon roads this presents a serious obstacle to the installation of heavy machinery. The localities[1] where productive mining has been reported are on Bear Creek and its tributaries and other streams in the Tuluksak basin. These placers are said to be nearly 100 miles distant from the Kuskokwim. In 1911 considerable excitement was caused by the finding of gold placers in the Anniak River basin. So far as can be learned, the discoveries made did not justify the inrush of miners which took place. It is reported, however, that several promising finds have been made and that a number of claims on Marvel Creek were worked in 1912. This stream is said to be about

[1] In the absence of any map of the region it is difficult to locate the scenes of reported discoveries. This difficulty is increased because a single stream may be called by two different names.

60 miles from the Kuskokwim. Another scene of active mining is on a stream called "Orolik" River, which is said to flow into the Kuskokwim from the east near the settlement of "Quinhagak" (Kwinak?) and which may be the stream marked on the official maps as Kanektok River. This is probably the same general locality as the placers which have been worked for several years in the so-called Goodnews Bay region. It is reported that a dredge is being installed in this district.

NORTHWESTERN ALASKA.

Seward Peninsula.—The value of the gold output of Seward Peninsula in 1912 is estimated to be $3,025,000; that of 1911 was $3,135,000. This small reduction is very significant in view of the fact that all forms of mining except dredging were much hampered by low water during the first part of the mining season. Dredging operations were also hindered by the unusual lateness of the spring. Considering these conditions, the gold output is remarkably large, and there is reason to believe that it has reached its minimum for many years to come.

There was an increase in the commerce of Seward Peninsula in 1912 compared with 1911. According to the records of the customhouse, 26,231 tons of general merchandise and 125 head of live stock were received and 1,603 passengers arrived at Nome in 1912, compared with 21,685 tons of merchandise, 31 head of live stock, and 1,514 passengers arriving in 1911. In spite of the fact that crude oil and gasoline are being largely substituted for coal as a source of power, 16,405 tons of coal were received in 1912, compared with 7,660 tons in 1911. In lumber alone the receipts in 1912 were less than those of the previous year.

When in any year there is a shortage of water for placer mining at Nome and other Seward Peninsula camps, it is often accounted for by the statement that the season was "unusually dry." As a matter of fact, the records go to show that since mining began at Nome in 1899 there have been only six summers during which there was any considerable rainfall. In other words, eight summers out of fourteen have been relatively dry. Many placer miners have been unwilling to accept the fact that the climate of Seward Peninsula is semiarid. The records kept for six years at Nome by Arthur Gibson show a total annual precipitation ranging from 9.46 inches (in 1909) to 18.31 inches (in 1911), with an annual average of 14.42 inches. The rainfall in the mountainous portions of the peninsula is greater[1] than at Nome, and this helps the flow of some of the streams whose

[1] Henshaw, F. F., and Parker, G. L., Surface water supply of Seward Peninsula, Alaska: U. S. Geol. Survey Water-Supply Paper 314, pp. 19-28, 1912.

waters are utilized for placer mining. While there are no complete records, it is probable that even in the mountainous parts of the peninsula the precipitation is less than 25 inches. Fortunately for the placer miner, about seven-twelfths of the precipitation takes place during the months from June to September, inclusive, and July and August are usually the wettest months in the year. These conditions of climate have been met by the introduction of dredges whose operation is less affected by low water than that of any other method of placer mining.

In classifying the gold production by districts and by method of recovery, the writer is much hampered by the fact that a number of the large operators fail to return promptly the schedules mailed to them each year. This neglect seriously impairs the accuracy of the statistics and undoubtedly hurts the mining industry. The following figures on the gold production are therefore based in part on estimates, but these are founded on the best data available.

The value of the output from the several districts in 1912 is estimated as follows: Nome, $1,150,000; Solomon and Casadepaga, $750,000; Council, $600,000; Fairhaven, $290,000; Kougarok, $160,000; Port Clarence, $50,000. It is of importance to the mining industry to know the proportion of gold derived from each form of mining. Neglect on the part of some of the operators to report production makes it possible only to approximate this classification. The best information available indicates that gold to the value of about $1,700,000 was recovered by dredging, about $1,040,000 by various open-cut mining methods, including some hydraulicking, and about $260,000 by deep mining. This is in strong contrast to the conditions a few years ago, when several million dollars' worth of gold was annually won by underground mining, and the output of the dredges was but a small fraction of the total.

During the year 31 gold dredges were operated in Seward Peninsula, compared with 22 in 1911. Three dredges, two of them small ones built previous to 1912, were not operated. The eleven new dredges installed in 1912 were operated for only a part of the season, a few making only test runs. Four dredges under construction were not completed in time for operating. In addition to these, a number of other dredging enterprises are under way. Most of the dredges which were completed in time began work about the middle of June, but some were delayed on account of the lateness of the season. The dredging season usually closes about the middle of October, but some were operated for a month or more longer. Of the dredges operated nine were located in the region tributary to Nome, nine in the Solomon River basin, two in the Casadepaga, six in the Council, two in the Kougarok, two in the Fairhaven, and one in the Port Clarence district. Eighteen of the dredges are reported to have a

bucket capacity of less than 2 cubic feet, six a capacity of 3 to 3½ cubic feet, three of 5 cubic feet, and four of 9 to 10 cubic feet.

The daily capacity of these dredges averages about 1,000 cubic yards. It is estimated that between 2,500,000 and 3,000,000 cubic yards of gravel was handled by the dredges during the year. If these figures are correct, it would indicate an average gold recovery of 52 to 64 cents a cubic yard. In considering these figures it should be noted that the average recovery per cubic yard is increased by the large output of a comparatively few dredges that are working on very rich ground.

Most of the dredges are excavating only material which is not permanently frozen. In a few places dredging ground has been artificially thawed. Janin [1] records one plant located near Nome which was thawing ground at a cost of 20 cents a yard, but there the gravels were only 8 to 10 feet deep. At present no thawing of deep ground has been successfully undertaken on any considerable scale.

Of the dredges operated in 1912 five use coal, four crude oil, twenty-two gasoline, and one, located in the Council district, wood. It is estimated that the equipment of these dredges aggregates about 4,000 horsepower. Two dredges, located near Nome, are operated by electricity, the power being furnished from a station equipped with a machine burning crude oil. Charles Janin,[1] an experienced engineer, who has given much study to the dredging industry of Seward Peninsula, has expressed the opinion that "it is doubtful if at the present time a central plant to generate electricity would be a profitable enterprise."

As already stated, underground mining operations are very small compared with those of a few years ago. Open-cut mining was seriously hampered by the lack of water, a condition which existed until about July 1, when some light rains fell. During August there was considerable rain, and during the second half of the season open-cut mining was done on about the same scale as in the previous year.

An item worthy of note is the discovery of placer gold in the southeastern part of Seward Peninsula, where there has been heretofore but little mining. In 1912 some mining was done on Placer Creek, a tributary of Koyuk River, and good prospects are said to have been found on Sweepstakes Creek, another tributary. Placer gold has also been found on two small creeks in the Darby Mountains not far from Golovin Bay.

Kobuk district.—During 1912 mining was continued in a small way in the Dahl and Squirrel river regions of the Kobuk district. The

[1] Janin, Charles, Gold dredging on Seward Peninsula: Min. and Sci. Press, Sept. 28, 1912, p. 398.

information at hand indicates that no important developments were made. It is reported that workable placers have been found on Lynx Creek. This stream flows into Kogoluktuk River, which in turn is tributary to the Kobuk about 3 miles east of Shungnak.

TIN MINING.

The York Dredging Co. continued in 1912 to operate its dredge in the tin placers of Buck Creek, in the western part of Seward Peninsula. Operations were begun on June 29 and continued until October 14. In the same district the lode-tin deposits of Cape Mountain were examined by mining engineers with a view to systematic development. The tin-bearing lode prospects of Lost River were taken over by a new company and systematic development of them was begun. About 300 feet of underground work was completed, and further developments have been planned.

NONMETALLIFEROUS DEPOSITS.

The nonmetalliferous deposits of Alaska that have been developed are coal, petroleum, marble, gypsum, graphite, and garnets. The marble-quarrying industry of southeastern Alaska is described elsewhere in this report (pp. 52–77). A little graphite was mined from a deposit in the Kigluaik Mountains of Seward Peninsula.

George C. Martin, who studied the ejecta of the Katmai Volcano (see p. 13), has suggested to the writer that this tuff might have value as an abrasive. The most accessible deposits [1] are on the shores of Amalik Bay, Alaska Peninsula, where there are accumulations 20 feet or more thick at the foots of cliffs and mouths of streams in close proximity to deep sheltered water.

Some sulphur deposits that have been found in the volcanic region of southwestern Alaska have attracted some notice. In 1912 it was reported that promising sulphur deposits had been found near Stepovak Bay, on the Alaska Peninsula. The following notes on gypsum and garnet mining in southeastern Alaska have been prepared by E. F. Burchard:

In 1912, as heretofore, only one gypsum mine was in operation. This mine, operated by the Pacific Coast Gypsum Co., was visited by E. F. Burchard, of the Survey, in October, 1912. The gypsum deposit is situated in the eastern part of Chichagof Island, about a mile from Iyoukeen Cove. The limits of the deposit have not yet been ascertained. At the surface the deposit is covered by gravel except near the shaft house, and no footwall nor hanging wall has been encountered in the mine workings. Several solution channels filled with gravel, more or less cemented, have been encountered in mining. The gravel is of the same character as that in the bed of Gypsum Creek. The gravel-filled channels extend below the 160-foot level. One channel has been tunneled for 35 feet without being cut through. Thin dikes of basaltic rock cut the gypsum beds, and a vein of anhydrite ranging in thickness from 6 inches to more than 10 feet has been encountered in the lower workings. This anhydrite is much harder to drill than the inclosing gypsum, and it is left in the

[1] Martin, G. C., The eruption of Mount Katmai of June, 1912: Nat. Geog. Mag., Feb., 1913.

mine. The gypsum is generally of a light bluish-gray color, although some is white, and occurs in massive beds which dip 30°–60° NE. The main body of gypsum is of a high degree of purity.

The mine shaft is 160 feet deep, with a 26-foot sump. The first level is at 75 feet and the second at 160 feet. The general trend of the gypsum deposit is in a direction slightly north of west, and the levels extend for 750 feet east and west and 270 feet north and south, with the shaft near the middle of the exploited area. Altogether, the underground workings are reported to measure probably 1 mile.[1] Overhand stoping is the method employed in mining, and considerable broken gypsum rock is stored in the stopes.

The gypsum is hoisted to rock bins of 1,200 tons capacity, from which it is dumped into tram cars and drawn by a steam locomotive to the wharf. Owing to a recent collapse of the old wharf about 2,500 tons of gypsum rock which had been stored in the bunkers were lost. A new wharf was under construction in 1912. It will carry bunkers near the middle instead of at the outer end, as on the old one, but the tramway will extend the whole length of the wharf. The production of gypsum from this mine, which began in 1906, was slightly curtailed during 1912, owing to the difficulty in loading rock while the new wharf was under construction, but a much larger output is assured for 1913. Shipments of crude gypsum are made by steam barges to Tacoma, Wash., where the material is calcined and manufactured into wall plaster of various grades in the company's plaster mill.

Adjoining on the east the claims now being worked for gypsum by the Pacific Coast Gypsum Co. and extending to the shore of Chatham Strait are other claims which have been located on reported deposits of gypsum.

Progress was made in the development of the garnet mine in southeastern Alaska, although no shipments of garnet are reported. This mine is situated on the mainland about 7½ miles north of Wrangell and is being developed by the Alaska Garnet Mining & Manufacturing Co. The garnets occur in an area of crystalline schist, principally in three ledges of dark-gray mica schist containing hornblende. Fresh exposures examined in September, 1912, by E. F. Burchard showed an abundance of garnets locally. The garnets are dark in color and are probably of the variety almandite, $Fe_3Al_2(SiO_4)_3$, in which the iron is present in the ferrous state. The crystals, which are for the most part remarkably symmetrical, consist of modified dodecahedrons and trapezohedrons, ranging in diameter from less than one-sixteenth of an inch to more than 1 inch, but generally between one-fourth and three-fourths of an inch. The garnet-bearing schist is being mined from open cuts and tunnels, and the garnets, which are easily loosened by splitting the schist, are stored in bins. As the garnets are too dark for gem material, it is probable that they will be utilized in the manufacture of abrasives.

Alaska coal fields continue to be undeveloped. The only coal mining done is that of lignitic coal for local use at Cook Inlet, on Seward Peninsula, and at several other localities. The total production in 1912 did not exceed 100 or 200 tons.

One company has continued operations in the Katalla oil fields in 1912, as in 1911. One of the two producing wells is said to have been sunk to a depth of about 800 feet. The oil is procured by pumping and is refined in a small plant located near Katalla. The gasoline finds a ready sale in the coastal settlements of this part of Alaska. There are several other oil companies which control property in this field, but these seem to have done little in the way of development during 1912.

[1] The above approximate measurements were furnished to the Survey by Mr. T. H. George, superintendent of the mine.

MARBLE RESOURCES OF KETCHIKAN AND WRANGELL DISTRICTS.

By ERNEST F. BURCHARD.

INVESTIGATION.

Studies of the marbles and other structural materials of southeastern Alaska were first made by F. E. and C. W. Wright in 1905 and by C. W. Wright in 1906, the results being published in Survey bulletins in 1906, 1907, and 1908.[1] Between 1908 and 1912 nothing was added to the reports on the subject.

In the autumn of 1912 the writer made a brief examination of the marble areas on Prince of Wales, Kosciusko, Marble, Orr, Tuxekan, Heceta, Ham, and Revillagigedo islands, and of the gypsum mine on Chichagof Island. This work occupied the interval between September 13, when a trip westward from Wrangell was begun, to October 12, when work was closed at Ketchikan. All the marble deposits that were producing and all that were being actively prospected except one on the west coast of Dall Island were visited, besides a number of known and hitherto undescribed areas of some promise. This paper discusses merely the economic features of the deposits. The petrologic character of the intrusive and metamorphic rocks associated with the marble deposits was determined by J. B. Mertie, of the United States Geological Survey, and the writer herewith expresses his appreciation for this service.

DISTRIBUTION OF THE MARBLE.

Beds of marble occur in places along the mainland in the Ketchikan and Wrangell districts and on many of the islands of the Alexander Archipelago, including Prince of Wales Island, Kosciusko Island, Dall Island, Revillagigedo Island, and several smaller islands mainly in Davidson Inlet on the west side of Prince of Wales Island. The principal developments that have taken place thus far are in the

[1] Wright, F. E. and C. W., Economic developments in southeastern Alaska: U. S. Geol. Survey Bull. 259, p. 68, 1905; The Ketchikan and Wrangell mining districts, Alaska: U. S. Geol. Survey Bull. 347, pp. 191–198, 1908.

Wright, C. W., Nonmetallic deposits of southeastern Alaska: U. S. Geol. Survey Bull. 284, pp. 55–57, 1906; Nonmetalliferous mineral resources of southeastern Alaska: U. S. Geol. Survey Bull. 314, pp. 73–77, 1907; The building stones and materials of southeastern Alaska: U. S. Geol. Survey Bull. 345, pp. 116–122, 1908.

northwestern and southeastern parts of Prince of Wales Island, on Marble Island in Davidson Inlet, and on Ham Island near the southeast point of Wrangell Island. The relations of all these localities are shown on Plate II and on the maps accompanying Survey Bulletin 347. The most detailed maps showing the geographic relations are the charts issued by the Coast and Geodetic Survey. Charts Nos. 8150 and 8200 show Ham Island southeast of Wrangell and the northwestern part of Prince of Wales Island and the neighboring islands; and chart No. 8100 shows Revillagigedo Island near Ketchikan and the southeastern portion of Prince of Wales Island. Both charts are on the scale of 1 : 200,000, or approximately 3 miles to 1 inch.

TOPOGRAPHIC AND COMMERCIAL RELATIONS.

The mainland of southeastern Alaska and the islands of Alexander Archipelago are generally mountainous. There is little level land either as upland area or along the shores. Along much of the coast line the hills and mountains rise abruptly, and the dense forest growth extending down to the level of high tide overhangs the steep banks. The islands are separated by an intricate system of deep waterways and fiords, known locally as straits, canals, channels, passages, sounds, inlets, bays, coves, and arms, some of which reach far inland. The topography is so rough that only in favored localities and at great expense can wagon roads or short tram railroads be constructed. The waterways are therefore of great value as affording routes of communication between different portions of the region and between the region and the Pacific coast ports of the United States. Indeed, were it not for water transportation the mining and quarrying industries in southeastern Alaska could scarcely have been developed.

Many of the marble beds are directly on the shores of sheltered bays, some of which are deep enough to afford anchorage or wharfage for ocean-going freight vessels. Some, however, are located on deposits a mile or more from the shore and at considerable altitudes. Naturally the deposits most convenient of access will be first developed.

The deposits are in general thickly overgrown with small to medium sized timber and dense underbrush and, as a rule, have a soil cover of decayed wood, moss, and mold from a few inches to 3 or 4 feet thick, but thicker in places in crevices in the rock. The timber consists of hemlock, spruce, and cedar, having in most places a maximum diameter of 4 feet, though exceptionally in the southern part of the area they may reach 6 feet. The following paragraph, by Wright, on the growth of vegetation is of interest here:[1]

> The luxuriant growth of vegetation along the coast of southeastern Alaska may well be compared with that of a tropical region. This is caused by the moist and

[1] Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska: U. S. Geol. Survey Bull. 347, p. 31, 1908.

temperate climate and the long summer days at this high altitude. At elevations below 1,500 feet bushes, ferns, and tall grasses grow profusely, especially in the valleys and gulches. These form in places a dense and almost impassable undergrowth and are a great hindrance to the prospector. Among the most common of these shrubs are the thorny devil's club, the salmonberry, the elderberry, the huckleberry, the high-bush cranberry, various willows, the black alder, and the white alder, the latter forming thickets along the streams and mud flats.

GEOLOGIC RELATIONS.

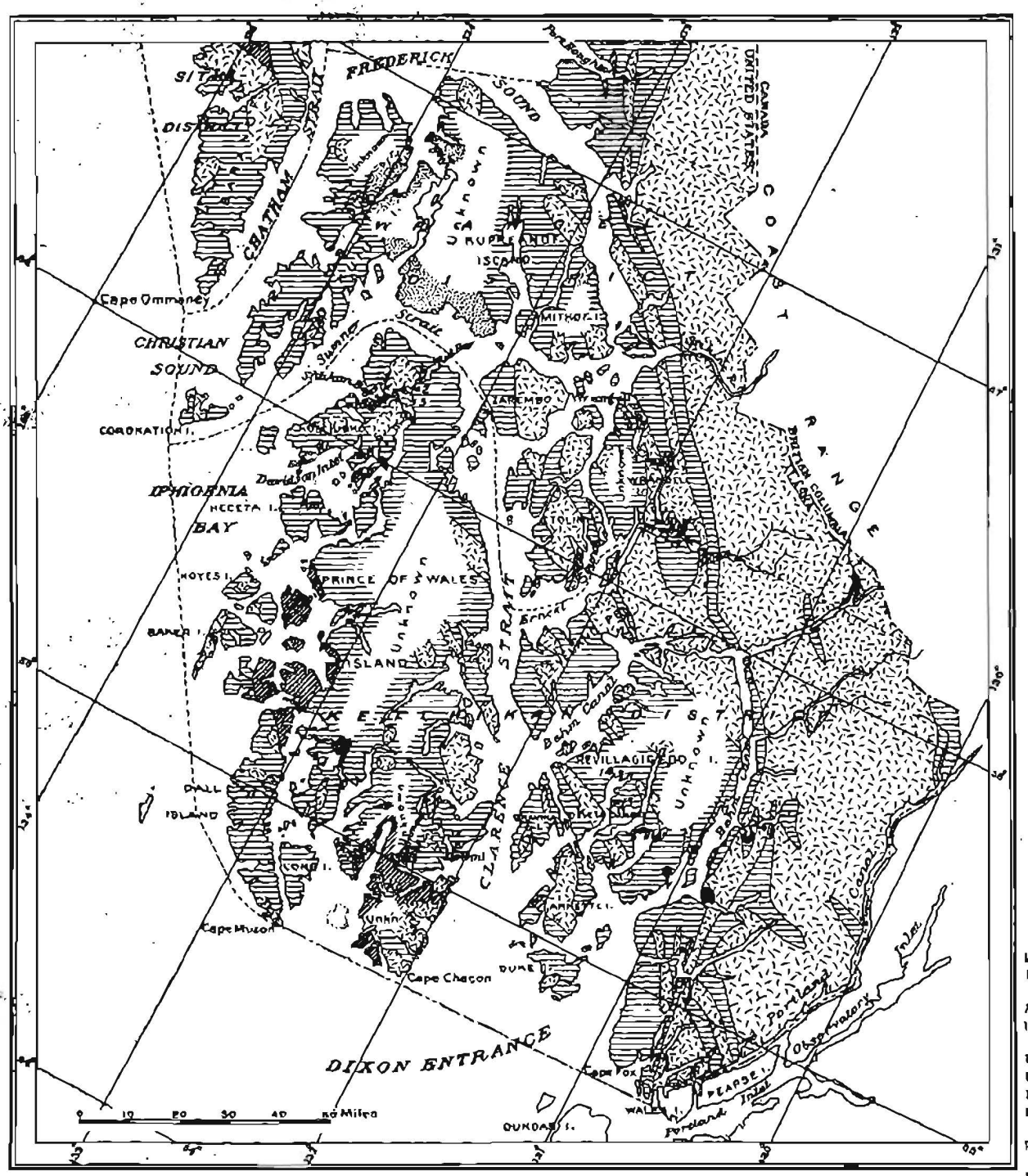
Most of the marble beds noted appear to be portions of extensive belts of limestone that have been metamorphosed at or near the contact of an intrusive mass of granodiorite. Both the limestone and the marble are cut in many places by thin dikes, principally of diabase, basalt, and andesite, all more or less altered and containing secondary calcite, and are interstratified with graywackes, schists, and tuffs. Both the limestone and the marble are generally much fractured and jointed, the marble in places showing joints open to considerable depths. The limestone beds associated with the marble deposits are of Paleozoic age and at a few places, notably in northern Prince of Wales Island and vicinity, are probably Lower to Middle Devonian.

TYPES AVAILABLE.

Several types of marble are available in southeastern Alaska. Probably the most common, and the only one which thus far has been exploited commercially, is a finely crystalline white to bluish-gray marble with gray to dark-bluish veins and clouded areas. Other crystalline marbles which give promise of being developed successfully show handsome contrasting "verde antique" effects and other striking combinations of color, such as green and pink, black and white, and white and yellow. The green color appears to be due to chloritic material and possibly to epidote, the bluish and black veins possibly to graphite, and the pink and yellow shades to iron oxide. Certain marble deposits give promise of affording statuary material. Some dense noncrystalline limestones have attractive colors of pink and chocolate mottled, gray, blue, and black and are susceptible of receiving a high polish.

QUARRIES AND PROSPECTS.

In the following pages the marble quarries and prospects are grouped geographically and are described as nearly as possible in the order in which they are numbered on the map (Pl. II). All the quarries and prospects that have made shipments of marble from Alaska are described, but a few claims located in the Ketchikan, Wrangell, and Juneau districts that have not been investigated by the Survey are omitted.



GEOLOGIC RECONNAISSANCE MAP OF A PORTION OF SOUTHEASTERN ALASKA

LEGEND

STRATIFIED ROCKS

Recent
(basaltic lavas and tuff)

Tertiary
(including sandstone, conglomerates, and rhyolitic lavas and tuff)

Mesozoic
(including graywackes, slates, conglomerates, and andesitic lavas and tuff)

Paleozoic
(including limestone, schist, phyllites, and pyroxenic lavas and tuff)

INTRUSIVE ROCKS

Granite, granodiorite, and diorite

Marble quarry or prospect

MARBLE QUARRIES AND PROSPECTS

1. Woodbridge and Lowery claims on Red Bay
2. Vermont Marble Co. claims south of Red Bay
3. Alaska Marble Co. quarry at Calder
4. Marble bluff north of Dry Pass
5. El Capitan Marble Co. quarry, north of Dry Pass
6. Claims south of Dry Pass
7. Vermont Marble Co. claims near Pyramid Peak
8. Vermont Marble Co. quarries, Marble Island
9. Mission Marble Works quarries, Orr and Marble islands
10. Waters claims, Hecata Island
11. St. Augustine, Evans, and Marble Heart claims, Dall Island
12. Claims near Dolomi
13. Alaska-Shamrock Marble Co. claims, Dickman Bay
14. Claims at Head of George Inlet
15. Claims on east side George Inlet
16. Spaulding claims, on Blake Channel
17. Vermont Marble Co. claims, Ham Island
18. Vermont Marble Co. claims, mainland east of Ham Island
19. Vermont Marble Co. claims, mainland southeast of Ham Island

NORTHERN PRINCE OF WALES AND ADJOINING ISLANDS.

RED BAY.

The calcareous rocks exposed along the shore of Sumner Strait at the north end of Prince of Wales Island are mainly fine-grained to dense bluish-gray limestone. Marble appears on the west shore of Red Bay about 2½ miles from the mouth, near the head of the bay, and beyond in the vicinity of Red Bay Mountain.

The marble on the west shore of Red Bay (No. 1, Pl. II) is fine grained and is mostly light colored, showing white, faintly to strongly clouded gray, and grayish-blue shades. The part exposed at the surface is rather soft. The beds are cut by several dikes of metadiabase, most of which are only a few inches thick, though one measuring 4 to 6 feet was noted. Thin irregular stringers from some of these dikes penetrate the marble in all directions. The marble exposed on the beach is jointed and, where weathered, shows slightly schistose planes that strike north-northeast. One bed of partly metamorphosed dark-bluish limestone, much fractured and having the seams filled with calcite, was noted interbedded with the marble.

Claims aggregating 80 acres extending about half a mile parallel to the beach and one-fourth mile inland, have been located on this deposit by Woodbridge & Lowery, who formerly located marble claims on Ham Island. Some prospecting has been done on the beach by hand and by blasting with black powder, and back of the beach, within the woods, the soil has been stripped and the surface of the marble bared in several pits and trenches, some of which are 140 feet long. The cover is 2 to 4 feet or more thick.

On the west shore of Red Bay, about three-fourths of a mile south of the Woodbridge & Lowery claims and separated from them by a body of dark intrusive rock, is an exposure of fine-grained light-gray to dark-gray marble. Samples from an exposure in the woods about 500 feet back from the beach and 60 to 80 feet above high-tide level are mottled. The weathered marble on the beach is very soft and appears slightly schistose, with the gray veins parallel to the schistosity.

Near the head of Red Bay, and between Red Bay Mountain and the head of a small lake about 1½ miles long which lies south of the bay, there are deposits of marble (No. 2) on which the Vermont Marble Co. has located claims. It is probable that this belt of marble extends southwestward nearly if not quite all the way to Dry Pass. The mass of marble opened at Calder has been traced a mile or more northeast from Dry Pass.

SHAKAN BAY.

Marble and limestone beds border the northeast shore of Shakan Bay, and the marble is well exposed in the entrance to Dry Pass in two small islands, on which are Indian graveyards. This marble is considered to be of Devonian age[1] and to have been altered by the intrusion of a granite mass which lies adjacent to it on the southeast. Claims 2 miles long and half a mile or more wide were located along the coast of Shakan Bay in 1905 by the Alaska Marble Co., after considerable prospecting by trenching and drilling to ascertain the extent of the marble and its quality in depth. A quarry (No. 3) has been opened near Calder at an altitude of about 100 feet on the hillside south of Marble Creek, about half a mile above its mouth, and an area of 100 by 200 feet has been stripped and quarried to a depth of nearly 100 feet measured on the hillside (about 60 feet below the level of the tramway).

The quarry is connected with deep water in Marble Cove by an inclined trestle, 3,200 feet in length, on which is laid a standard-gage railroad track. Loaded cars run down to the wharf by gravity and are drawn back to the quarry by cable. The wharf is equipped with a stiff-leg derrick and the quarry with two derricks, necessary channeling and gadding machines, and a complete machine shop. The power plant near the quarry which operates the quarry derricks and the tramway cable is equipped with an 80-horsepower boiler. A small engine on the wharf operates the derrick there.

The character and relations of the marble deposit are described as follows by the Wright brothers,[2] who visited this locality while active work was in progress.

> The extent of the marble deposit at this locality has been investigated at a number of points on the surface by open cuts and trenches and in depth by eighteen drill holes, and at all of these places marble usually of good quality is exposed. The marble belt is approximately 3,000 feet in width, striking in a northwesterly direction and dipping to the southwest. It is limited on the northeast by an intrusive granite mass and on the southwest by the shore line. To the south it crosses the entrance to Dry Pass, but just back of Shakan it is cut off by a granite mass, while to the northwest it extends into the channel and reappears at the entrance to Calder Bay, extending northward and overlying beds of conglomerate. Along the shore exposures and at the quarry small dikes of diabase, striking northeasterly and much altered and faulted, were observed intersecting the marble beds. Apparently these dikes antedate the metamorphism of the limestone and therefore the intrusion of the granite. They are, however, but a foot or two in width and not sufficiently numerous to affect the value or expense of quarrying the marble. In the present opening at the quarry only one dike is exposed. Both surface cracks and slipping planes are present in the surface exposures of the marble, but in depth these are less numerous and will not materially interfere with quarrying.

[1] Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska: U. S. Geol. Survey Bull. 347, p. 192, 1908.

[2] Idem, pp. 194–195.

Three distinct varieties of marble are found—pure white, blue-veined with white background, and light blue, often having a mottled appearance. The pure white, which has a finely crystalline texture, is the most valuable. All of the marble is free from silica and flint beds common in most quarries, and though thin seams of pyrite were observed they do not occur in a quantity detrimental to the stone. The following chemical analysis of the white marble was made by E. F. Lass for the Alaska Marble Co.:

Chemical analysis of white marble from Marble Creek, Prince of Wales Island, Alaska.

Insoluble matter	0
Oxide of iron (Fe_2O_3)	Slight trace.
Sulphuric anhydride (SO_3)	Trace.
Lime (CaO)	55.59
Magnesia (MgO)	.30
Carbon dioxide (CO_2)	43.67
Undetermined	.44
Total	100.00
Calcium carbonate ($CaCO_3$)	99.26

A qualitative test for magnesia in a sample collected by the writers was made by Dr. George Steiger, of the United States Geological Survey, who reports a content of less than 1 per cent.

To determine the crushing strength of the stone the Alaska Marble Co. submitted samples to N. H. Winchell, State geologist of Minnesota, who reports an average strength of 10,521 pounds per square inch, a strength ample for all building purposes. Though not equal to the best Italian grades, this marble is better than most American marbles and in the market will compete on at least equal terms with the product of Vermont, Georgia, and Tennessee.

A thin dike of metabasalt at this quarry was noted to contain much pyrite and a streak of pyrrhotite.

Experience in quarrying this marble seems to have shown that the whiter varieties are softer than the veined or clouded varieties. Areas in which the rock is too soft for commercial purposes are not uncommon, even in the depths of the quarry. The marble beds are much fractured and as yet the fractures have not been found to entirely disappear with depth. A vertical hole is reported to have been bored with a core drill 175 feet below the present bottom of the quarry, and two more holes were drilled in the southeast and southwest corners of the quarry for distances of about 200 feet at an angle of about 45° to the horizontal. All these cores are reported to have shown marble of good quality.

Shipments of marble were made from this quarry each year from 1906 to 1910, but no quarrying has been done since December, 1909. The product in rough blocks was shipped mostly to a sawing and polishing plant at Tacoma, Wash., where it was prepared for interior decorative purposes. Shipments were also made to Spokane and San Francisco and to several eastern cities. The passing into other hands of the Tacoma mill which handled the output of this quarry is

said to have been one cause for the closing of the quarry, but it is probable that another was the failure to find sufficiently hard stone within the depths quarried. According to recent reports it is planned to reopen this quarry in the spring of 1913. All the equipment has been kept in good condition.

DRY PASS.

The marble area extends eastward from Calder about 2 miles along the north side of Dry Pass to a small shallow cove known as Winter Harbor, just east of the shallowest part of Dry Pass, where it terminates against a mass of gray granite. The marble in this vicinity is white to light grayish blue in color and is very coarsely crystalline near the contact with the granite. On the surface it is not very hard and is easily disintegrated to sand by water running down the slopes. On the northeast shore of the small cove the marble forms low cliffs, over one of which, at the north end of the cove, falls a small mountain stream. One-half mile above the mouth of this creek a cliff of gray, coarsely crystalline marble (No. 4) 100 feet high surmounts a talus slope about 200 feet high, which extends from the creek to the cliff. The top of the marble cliff is probably 500 feet above sea level. The general trend of the ridge is N. 60° E., and the marble mass may be continuous with the deposits located by the Vermont Marble Co. south of Red Bay. Between Winter Harbor and Shakan Bay the marble beds are cut by several dikes and are intruded by small areas of basaltic rock.

On the north side of Dry Pass, about 2½ miles east of Winter Harbor, on the east side of the granite mass just mentioned, marble beds (No. 5) form the surface rocks for a mile or more. Ten marble claims located here were sold to the El Capitan Marble Co. in 1903. In 1904 a small quarry pit 12 feet deep was opened near tidewater by channeling and gadding machines, and three gangsaws operated by steam power were installed. A small quantity of marble was shipped to Seattle. Operations were suspended at the close of 1904 and have not been resumed, although the property has been cared for and it is rumored that the quarry will be reopened in 1913.

The marble exposed in the El Capitan quarry, though not very firm, is of slightly coarser texture and shows more contrast than the marble at Calder. It is white with faint gray veins and cloudy areas. The exposures near the beach are badly fractured. In one set of fractures, which strikes N. 60° E., nearly all the openings are filled with quartz, which stands out in relief on the weathered surfaces. These quartz seams are nearly vertical and are spaced from 3 or 4 inches up to many feet apart. A small geode of quartz crystals was noted in the marble exposed in the wall of the quarry pit. The

presence of siliceous material in the marble may render the stone slightly difficult to saw uniformly. Several metadiabase dikes cut the marble beds. Near the quarry one which is much jointed and has been faulted and deformed ranges from 12 to 18 inches in thickness, strikes N. 40° E., and dips steeply southeast. Wright considers that the dikes were intruded and later disturbed, all, however, prior to the metamorphism of the limestone beds.

In the bluffs northeast of the El Capitan quarry at 200 to 400 feet above sea level are exposures of medium-grained bluish-gray marble which has been prospected by pits and trenches, and about one-half mile above the mouth of a small creek that empties near the sawing plant are exposures of very fine grained white marble, all of which are included within the El Capitan group of claims.

KOSCIUSKO ISLAND.

On Kosciusko Island, on the opposite side of the channel from the El Capitan marble claims, are exposures of marble (No. 6), most of which is grayish although some is nearly white. This marble is rather fine grained and is cut by fractures filled by siliceous seams like those on the El Capitan property. These seams are one-sixteenth to one-fourth inch thick, are spaced from 4 inches up to 4 feet apart, strike N. 50° E., and are nearly vertical. Toward the east and south along this shore of Kosciusko Island the marble gradually changes into less metamorphosed limestone. At Aneskett Point the rock is a dense fine-grained limestone, much fractured and seamed with calcite.

In the western part of Kosciusko Island, between the southwest base of Pyramid Peak and the head of Tokeen Bay, three claims of 160 acres each (No. 7) have been located by the Vermont Marble Co. This marble lies just south of the granitic mass that has produced the metamorphism of the marble deposits of Calder and the El Capitan claim farther north. The deposit is exposed for about 200 feet in a steeply sloping bluff 20 to 30 feet high on the left bank of a small mountain creek that flows southwest into Tokeen Bay about one-half mile distant. At the lower end of the exposure the marble is dark bluish gray and fine grained, but the greater part of the deposit is medium grained and white and is thinly veined with dark-gray or yellowish seams. On the exposed face the marble is very soft, almost saccharoidal, and it was difficult to obtain a sample firm enough to be carried away. The beds are cut by numerous joint planes. Prospecting has been done by blasting and by core drilling nearly at right angles to the face, which seems to represent a steep dip slope. The prospects are located about 200 feet above sea level. To transport the marble to tidewater it would be necessary to build one-half to three-fourths of a mile of tramway through some rather rough country.

On the southwest shore of Kosciusko Island northeast of Edna Bay outcrops of dull to dark gray limestone alternate with narrow areas of graywacke for 2 miles or more. The limestone is cut by basaltic dikes and is everywhere badly cracked and at the contact with some dikes is locally metamorphosed to marble. The marble thus produced is probably not of uniform quality nor of sufficient extent to be of commercial value. About 2 miles northeast of Edna Bay a small area of red and white mottled limestone was noted.

MARBLE AND ORR ISLANDS.

GENERAL FEATURES.

The most extensive developments of marble in southeastern Alaska are in the northwestern part of Marble Island, one of the larger islands in Davidson Inlet, on which marble was first discovered in 1899. Quarrying has also been begun on Orr Island, just across the narrow inlet from Marble Island.

Marble Island extends about 3 miles from east to west and about 4 miles from north to south. Its surface is densely wooded and is generally of moderate relief, the highest point noted by the Coast and Geodetic Survey being 1,528 feet above sea level. According to the mapping of the Wrights[1] the rocks of both Marble and Orr islands are classified as limestone and other sedimentary rocks, together with schists and volcanic tuffs, all of Paleozoic age. Much of the limestone in this area has been metamorphosed to a high-grade marble.

VERMONT MARBLE CO.'S CLAIMS.

Certain marble claims that were located in the northwestern part of Marble Island in 1903 have been purchased by the Vermont Marble Co., which has opened a large quarry (No. 8) and built a small village named Tokeen. The total area held by the company aggregates 703,246 acres, according to the plat of mineral survey No. 927, made by L. D. Ryus, deputy mineral surveyor, of Ketchikan.

Blue limestone.—The marble in the quarry is massive and has yielded no fossils except crinoid buttons, but it overlies thin-bedded dark-blue limestone which has yielded fossils of probable Middle Devonian age, consisting of Favosites and Spirifer (?), as determined by Edwin Kirk, of the United States Geological Survey.

Southwest from the Tokeen wharf, along the shore of the island, an alternation of limestone beds, intrusive rocks, and marbles occurs, but around the cove in which the wharf is situated the dark-blue limestone outcrops and has been stripped over an area about 50 feet square preparatory to quarrying sample blocks. The rock is fine grained and dense but is much fractured and jointed, the openings

[1] Wright, F. E. and C. W., op. cit., Pl. I.

having been cemented with white calcite. The beds range from 1 foot or less to 3 feet in thickness, but on weathering separate into thin layers 1½ to 5 inches thick. The joints separate the rock in places into small blocks only 1 inch to 3 or 4 inches on an edge. The material is reported to take a fine dark polish. The rock is very brittle and breaks easily, not only along the calcite-filled joint cracks but also along the laminations parallel to the bedding planes. Probably most of the surface material will have to be rejected, but with depth the joint cracks may become fewer and the rock stronger. The white calcite streaks that intersect the dark surface produce very attractive effects in the polished stone.

The overburden consists of forest growth and decayed wood and mold 1½ to 3 feet thick. The rocks dip 38°–40° NE., and the edges of their tilted beds have been cut by solution into a very irregular surface. The tramway from the wharf to the marble quarry passes the opening on the blue limestone, so that the material can be handled with a minimum of expense.

White and veined marble.—Eastward from Tokeen the blue limestone passes beneath the deposit of marble, which extends to and probably far beyond a small bight on the north side of Marble Island, 400 feet from the quarry. The belt of marble and blue limestone is probably 2,500 feet or more in width, and it extends southeastward into the interior of the island for a much greater distance—possibly entirely across to Orr Inlet. The color of the marble ranges from nearly white with dark-gray and black veins to light-gray to grayish-blue shades. The grain is medium fine and fairly uniform. The marble takes a good polish and is said to resemble certain grades of Italian marble. Iron pyrites grains are exceptionally present. The marble having dark veins on white background is very much in demand at present for interior decoration. Blocks are sawed into slabs, which may be matched so as to form certain nearly symmetrical patterns. They have been used in a number of buildings. (See pp. 76–77.)

The marble appears to be wholly metamorphosed. The material is massive and shows no indication of its original bedding, but it is much jointed and fractured and within 10 to 20 feet of the surface is rather soft. The joint planes cut the deposit at many angles but may perhaps be referred to several systems, the two principal ones striking about N. 50° E. and N. 40° W. The dips of the joint planes are likewise at many angles, and the spacing of the joints is variable, ranging from a few inches to 10 feet or more. In places parallel joints, or "headings," are rather close together, rendering it impossible to obtain blocks large enough for shipment, but in other places blocks 4 by 4 by 10 feet free from cracks may easily be obtained. Wedge-shaped blocks that are completely separated from the sur-

rounding mass by smooth joint planes are occasionally encountered in quarrying. Near the northeast side of the main quarry the marble is cut by a dike of altered andesite porphyry, 8 to 16 inches thick, containing much pyrite and dipping 17°–25° NE.

The jointed structure of the marble is the most serious hindrance to its profitable exploitation. It is to be expected that joint cracks should be present at the surface and that surface water should descend along these cracks, enlarging them, softening the marble, and oxidizing it to a faint yellowish hue, but, according to experience in many other regions, it might be expected that at depths of 40 to 60 feet the joint cracks would disappear and the marble become solid. So far as quarried (60 feet), however, it still shows joint cracks in places.

Quarries.—The main quarry operated by the Vermont Marble Co. on Marble Island in 1912 is situated about 900 feet northeast of the shore of the small cove at the northwest corner of the island, at an altitude of about 15 feet above the wharf. In places bare knobs of marble are exposed in the vicinity of the quarry, but the surface of the marble, which is very irregular as a result of solution and running water, is generally covered by 1½ to 3 feet of decayed wood and mold. In places the roots of trees have followed the crevices in the rock to depths of 5 or 6 feet. Trees and stumps are removed by derricks and the soft mold by hand. The first small opening was abandoned at a depth of about 20 feet on account of several joint cracks 1 to 6 inches or more apart in the northwest end of the cut. These joints dip steeply toward the north, and the quarrying was shifted far enough northwest to avoid them for a time. This dip, however, brings them back into the quarried area at a depth of about 50 feet, and at 60 feet they are apparently about as numerous as at the surface.

In September, 1912, the top of the opening of the quarry measured roughly 90 by 100 feet, and the depth ranged from 10 to 60 feet. About one-half of the area had been quarried to the maximum depth. Methods of quarrying commonly in use at well-known marble quarries in the Eastern States are employed. The equipment in the main quarry consists of the necessary drills, seven Sullivan single channeling machines, four gadders, and pumps, all operated by steam power generated by a 125-horsepower boiler near the quarry, and a complete machine shop.

The blocks of marble are lifted from the quarry by a 25-ton derrick and are carried to the wharf on flat cars running on a standard-gage track. The loaded cars move by gravity and are drawn back to the quarry by a $\frac{7}{16}$-inch steel cable. Waste rock is also trammed down to the wharf and dumped into the water alongside the pier. Deep water is reached by a pier about 150 feet long. A 25-ton stiff-leg derrick for unloading cars and loading marble on boats is operated by a small steam boiler on the shore near the wharf.

In September, 1912, a space of 1½ acres about 375 feet southeast of the main quarry was being cleared for a new quarry. The highest knobs of marble rise here to about 35 feet above the level of the wharf. The marble at this new opening is chiefly white with bluish-gray veins and clouds similar to that already being quarried but apparently contains areas of more handsomely veined stone. One dike of meta-andesite 1½ to 2 feet thick, striking N. 35° W. and dipping 78° SW., was noted. A large derrick is used for stripping.

About 60 men were employed in connection with this plant in 1912. The men live in sanitary and comfortable dormitories, eat excellent fare at a commodious mess hall, and enjoy such generally favorable conditions under which to work that they show a high degree of efficiency. Quarrying is carried on for eight or more months during the year. The winters are not severe, and operations may be carried on throughout most of the year as soon as pipes from a reservoir are laid underground so that there shall be no danger of interruptions by freezing of the water supply.

Products.—Rough blocks 4 by 4 by 6 feet to 4 by 4 by 10 feet are shipped by freight steamers to the mill of the Vermont Marble Co. at Tacoma, Wash., where they are sawed, polished, turned, or planed, for interior decorative purposes. To save freight only perfect blocks are shipped, necessitating the wasting of considerable material. According to the absence or presence of joints the proportion of waste marble quarried may vary between 10 and 75 per cent. The marble for a foot or more on each side of most fractures is discolored and must be cut away. If a fracture crosses the block diagonally or near the middle, it may render the whole block worthless. If cheap power were available it might prove an economy to operate a small sawing plant at Tokeen in order to work the waste marble into slabs.

Other prospects.—The Vermont Marble Co. has prospected claims about 1 mile and 1½ miles southwest of Tokeen. At one point a white marble is exposed in a small hillside quarry from which, it is reported, marble was obtained many years ago for making tombstones. The surface marble here has been softened by long exposure to atmospheric agencies, and none from any considerable depth was available.

At a second place several variegated marbles have been exposed by prospect pits. The most characteristic varieties are colored light to dark green, bluish, mottled light pink, and brownish gray. The mottled character is due to the presence of chert veins and nodules. The green varieties are veined with grayish green, darker than the body of the rock. The rock is massive and jointed and is cut by a thin dike of meta-andesite striking N. 40° W. The deposit was prospected by three or four drill holes, 60 to 94 feet deep, which showed that the green stone changed to gray or bluish within 15 to

25 feet from the surface. A small area was next stripped by hand and two or three shallow pits were opened by a channeling machine in the hope of developing a supply of desirable green marble. A wooden track on an incline was built from the test pits a short distance down to the water in order to get out a few sample blocks of stone, but the operations have been discontinued on account of the scarcity of stone of uniformly strong green color.

Between these two prospects there is a beach about 1,600 feet in length, along the greater part of which marble beds are exposed. The marble is veined and is white to grayish in color. It is cut by several meta-diabase dikes 8 inches to 2½ feet thick, some of which are broken and distorted. One dike noted had been faulted and offset horizontally a few feet, but the marble which filled the space between the broken ends of the dike showed only a flowage structure without a definite fault plane. The intrusion of the dike and the deformation of the beds through which it passes probably preceded the metamorphism that produced the marble.

Limestone, alternating with graywacke, the former slightly metamorphosed in places but generally a fine-grained bluish rock much fractured and seamed with calcite, forms the coast line around most of the west and south sides of Marble Island. A considerable area of true marble, however, occurs along the middle of the east side of the island and on the west side of Orr Island, which is separated by a narrow channel from Marble Island.

MISSION MARBLE WORKS.

A group of claims lying on both Marble and Orr islands and crossing the channel between them is under development by the Mission Marble Works, of San Francisco, Cal. On Marble Island the rock is nearly white and grayish blue. The light-colored marble lies south of the blue marble and apparently overlies it, although the stratigraphic relations of the two varieties are not wholly clear. A small bluff of white marble is exposed at the water's edge almost directly opposite the quarry on Orr Island. This marble is massive and of medium grain for 15 to 20 feet above the water. Higher up the slope the weathered surface shows thick layers, and the grain is somewhat finer. Only a small amount of prospecting has been done here.

The blue marble outcrops in a low swampy tract along the shore about one-half mile northeast of the bluff of white marble. It is dense, hard, and fine grained and shows white calcite streaks along bedding and joint planes. It appears to be more nearly a true marble than the thin-bedded blue limestone at Tokeen, which it nevertheless resembles somewhat in character. Weathering has accentuated the bedded character of the rock along exposed edges.

The dip of these beds is steep toward the northwest. A little prospecting and sampling have been done on this deposit in the way of assessment work.

On the Orr Island portion of the property (No. 9) considerable prospecting and development have been done, affording better opportunity for inspection than on Marble Island. The timber has been cleared along the water front and a space about 50 feet square has been stripped and opened for quarrying about 25 feet above high tide. The overburden is similar to that at the quarries of the Vermont Marble Co. (p. 62). The surface of the marble is much furrowed and pitted by solution, and joints and fractures are numerous, being spaced from a few inches to several feet apart, but they seem to close up and to become fewer even in the little depth penetrated by the quarry. The marble exposed is of medium grain, cream-colored to bluish white, veined with dark gray, and in places shows mottled effects. Near the surface the veins producing the mottling are oxidized to a brownish color. The appearance of the mottled stone suggests that it may have been derived from a conglomerate. Both the veined and the mottled types of stone are handsome in the rough and give promise of showing up finely when polished. The marble in the north side of the quarry is cut by a dike of andesite, somewhat altered and containing considerable pyrite. For most of its length the thickness of this dike ranges from 2 to 6 feet, but it thins abruptly and terminates in a few irregular branching veins only a fraction of an inch in thickness. This dike strikes about S. 30° E. and dips steeply northeast. A similar and approximately parallel dike was recognized at a prospect about 100 feet northeast of the quarry.

When visited in September, 1912, the quarry had been opened to a depth of about 11 feet only, and for the most part the surface rock had not yet been removed. Two drills and two channelers, both of the Ingersoll type, were in operation and six or seven 10-ton blocks of marble from the second bench of the quarry were ready for shipment. The first consignment of blocks from this quarry reached San Francisco in February, 1913. The quarry is equipped with hand-power derricks capable of lifting blocks weighing 10 to 15 tons. The marble will have to be carried by scows from the quarry southward about 1 mile and transferred to freighters in deep water. Marble outcrops at intervals for several hundred feet along a low bluff parallel to the beach and has been shown to underlie the whole group of claims, but its depth and soundness have not been demonstrated by the drill.

SEA OTTER SOUND AND DAVIDSON INLET.

In order to verify several reported occurrences of marble on Tuxekan, Heceta, and smaller neighboring islands a trip was made around practically all the remaining shores of Sea Otter Sound and Davidson Inlet, as well as into Tuxekan Passage and Tonowek Bay. The calcareous rocks bordering these shores proved to be for the most part nonmetamorphosed limestone, principally of the gray or blue fine-grained brittle type, with fractures filled with calcite. Near the middle of the north side of Heceta Island (No. 10) an exception to this type of limestone was noted in the occurrence of a limestone colored pink, chocolate, green, and white, with mottled effects. The stone is fine grained, hard, and dense and should take an excellent polish. It has been somewhat fractured and recemented with calcite, but it is not metamorphosed, and it yielded a few fossils, among which were recognized Conchidium and a pentameroid(?). These forms, according to Edwin Kirk, are not much younger nor a great deal older than Lower to Middle Devonian. This limestone outcrops at the head of a small bay and was traced inland for about 300 yards and to an altitude of 50 feet or more above high tide. In places the colors are much paler, but the mottled character persists and much stone is attractively colored. An area of graywacke borders this limestone on the west and north. Claims have been located on this mottled limestone by W. C. Waters. No marble was found on any of the smaller islands within this area, although trips were made to Cap, Hoot, Owl, Eagle, Whitecliff, and Green islands.

DALL ISLAND.

Samples of marble obtained near Waterfall Bay (No. 11), on the west coast of Dall Island, were seen by the writer at Ketchikan. He had no opportunity to visit the locality but found the samples to be of much merit. The principal colors are white, pink, gray, and blue. The white and pink varieties are very handsome, the pink occurring in various delicate shades and in areas mottled with white. Green marble is reported to occur but has not been much prospected. The white and pink varieties appear to have been wholly metamorphosed, but the gray and blue varieties appear to possess the characteristics of little-altered limestone. The grain of all the samples is fine, that of the gray and blue varieties being exceedingly fine. In the lighter-colored varieties calcite crystals larger than the average are exceptionally present, but in general the texture is uniform and thin pieces of the stone are as translucent as alabaster. This marble takes a very high polish.

The marble deposits are reported by M. D. Ickis, of Ketchikan, to lie about the head of Waterfall Bay, about the middle of the west

coast of Dall Island. Twenty claims in all, totaling 400 acres, have been located under the names Eurus, Marble Heart, St. Augustine, and Marble Bay groups. Openings have been made about 300 feet above tide level and about 1,000 feet from the beach. The geology of the western part of Dall Island has not been mapped by the Survey, but Mr. Ickis reports that the rocks in the vicinity of Waterfall Bay consist of limestone, marble, schist, and granitic rocks. On the east coast of the island, within 7½ miles of Waterfall Bay, the country rock is shown to be greenstone lava flows interstratified with volcanic tuffs and black slate, bordered both to the north and south by Paleozoic sedimentary and eruptive rocks.[1] A few dikes of "trap" rock 1 foot to 4 feet wide are reported to cut the blue marble beds. The rock is probably much jointed, as many of the samples shown to the writer displayed one or more smooth joint faces. Blocks of the pink marble only 2 to 3 inches wide have been produced by parallel joints. It is reported that enough marble is available in these claims to warrant development and that several thousands of dollars have been expended in prospecting.

SOUTHEASTERN PRINCE OF WALES ISLAND.

DOLOMI.

Certain marble deposits (No. 12), on the east side of Prince of Wales Island in the vicinity of Dolomi were described by the Wright brothers,[2] and as no new work has been done on the claims they were not visited by the writer. The notes as originally published are given below:

The properties of the American Coral Marble Co. are located at two localities—(1) at the head of North Arm, where 12 claims have been located along the north shore of the inlet, and (2) at the north entrance to Johnson Inlet, where the company has several claims extending from Dolomi eastward to Clarence Strait. The principal developments have been made at the North Arm property, and at this point a post office named Baldwin has been established. Active work at this locality began in 1904, and the marble deposits were prospected during that year. In 1905 a wharf was built, machinery installed, and buildings erected preparatory to quarrying the marble. During 1906, however, practically no work was done, and all of the machinery was removed in 1907. At the Dolomi property a small quarry was started on the hillside, at a point a quarter of a mile northeast of Dolomi post office and a few hundred feet from tidewater on the Clarence Strait side, and buildings were erected. No operations were in progress at these localities during 1907 [nor in 1912—E. F. B.].

The deposits at North Arm and at Dolomi consist of marble beds interstratified with chloritic and calcareous schists, striking northwest with steep dips, usually southwest. The surrounding area is mantled by a dense growth of vegetation, and the limits of the deposits have not been definitely determined, though where the marble is exposed it is much fractured, variable in color and composition, and intersected by a few narrow dikes of diabase. The fracture planes were probably formed principally during the period of tilting and folding of the beds and existed before erosion exposed the

[1] U. S. Geol. Survey Bull. 347, Pl. I. [2] Wright, F. E. and C. W., op. cit., pp. 196–197.

present surface outcrops. Since that time weathering has accentuated and to some extent increased the number of fracture planes, and it seems probable, however, that in depth these planes, although potentially present as lines of weakness, will become less numerous and will not interfere greatly in quarrying.

Although some parts of the deposits consist of pure-white fine-grained marble of excellent quality, other parts are poorly colored, coarse grained, and of little commercial value, and it will probably be difficult to obtain large quantities of uniform grade. The better grade is reported to give the following analysis: Calcium carbonate, 94 per cent; alumina, 3.9 per cent; silica, 1.4 per cent; magnesia, 0.7 per cent. Pyrite is also present in small amounts, occurring in thin seams and finely disseminated in some of the marble.

DICKMAN BAY.

Location.—An area of particular interest on account of the large variety of marble which it affords is situated in southeastern Prince of Wales Island in the peninsula between Dickman Bay (so named on Coast and Geodetic Survey chart No. 8100) and the unnamed narrow inlet to the northward, here designated Shamrock Inlet. Dickman Bay is an extension of West Arm of Moira Sound, and the area lies 11 to 12 miles southwest of Dolomi. Twelve claims of approximately 20 acres each (No. 13) have been located here by Francis Clarno, of Portland, Oreg., and others, and are being developed by them under the name Alaska-Shamrock Marble Co.

Relations and character of the marble.—The marble occurs in beds of varying thickness which strike N. 30°–40° W. and dip steeply southwest. The marbles are interstratified with graywacke and schistose beds and are intersected by dikes of diabase and basaltic rock. A small area of dark-gray granitic rock is exposed at the southeast point of the peninsula and appears to border the marble mass on the southwest. The marble is more or less schistose in places, especially near the contacts of schistose beds, and it is banded locally near the contacts of dikes by the interlamination of marble and dike rock, the laminæ ranging from less than 1 inch to several inches in thickness. Ledges of marble 50 to 75 feet wide alternate with areas of graywacke 50 to 1,000 feet across and have been traced in the direction of the strike for a mile or more. The surface exposures show more or less jointing and fracturing of the beds.

The surface of the peninsula north of Dickman Bay is rough and wooded. The banks generally rise abruptly from deep water, and the highest marble ledges reach an altitude of 350 to 500 feet above sea level at a few hundred feet from the shore.

Generally the marble on the Alaska-Shamrock claims is of fine grain, although in a few places a little coarsely crystalline material was noted. A large number of samples sent from the prospects to Portland, Oreg., have been polished and have revealed a large variety of colors in a great many combinations. As a rule the rocks take a good polish. Where the marble is strongly veined, or schistose,

the veins which produce the beautiful effects in the marble do not take so uniform a polish as the calcite portions of the stone. The differences in the polish are due to the presence in the veins of minerals, such as quartz, mica, and chloritic materials, of varying degrees of hardness, and are not noticeable unless the light falls on the surface at an angle.

Certain of the varieties of marble obtained here, according to color combinations, are white with golden-yellow veining; grays of various shades; gray, veined and mottled with white, pink, and yellow; pale green, grass-green, green with black and white, green with pink and white, black and white, plain black, and other combinations. In thin sections the green color appears to be due to chloritic material and possibly to some epidote. Among the trade names adopted by the company to designate some of the more striking varieties of the marble are "white and gold," "Confederate gray," "moss-agate green," "raven-black," and "jewel marble." The last is a veined or mottled stone generally showing strong contrasts between dark green, white, and pink and having a few pink calcite crystals either isolated or in bunches. The color of these calcite crystals, which suggests that of garnet, is due to the presence of disseminated fine grains of hematite.

Prospects.—Three or four openings have been made on marble beds that outcrop on the shore of Shamrock Inlet. At the prospect nearest the southeast point of the peninsula work was in progress in October, 1912. A small clearing had been made, several houses and a machine shop had been built, and blocks were being detached from a ledge of marble banded with dark-gray and white veins. The marble is brittle and somewhat schistose and splits readily along the laminations. On weathered surfaces the harder portions of the rock stand in relief above the more calcareous portions. A hand derrick was used here in clearing away stumps and raising blocks of marble.

Northeastward along the shore of the inlet other openings disclose alternations of light-colored and blue marble. One opening is in beds of very fine grained cream-colored marble slightly veined with yellow. At this place the beds are exposed for about 100 feet horizontally and 30 to 40 feet vertically. The strike is N. 75° W. and the beds stand nearly vertical. The surface of the beds is rough and fractured with deep crevices produced by solution, and the mass is cut by a basaltic dike which has been faulted and twisted since its intrusion into the marble. Where badly fractured the beds will have to be quarried deeply in order to ascertain the possibility of obtaining adequate-sized blocks.

Two of the most interesting prospects are on a ridge extending northwest from the settlement, in the direction of the strike of the rocks. The marble ledge that has been opened is 70 to 75 feet wide

between two dikes that have weathered more slowly than the calcareous mass and that form walls on either side of it. At the upper opening, about 800 feet from the shore and 350 to 400 feet above tidewater, the marble is principally green. The beds are exposed for about 150 feet along the strike. The green color appears to become paler toward the northwest, although small patches of stone among the paler areas are fully as deep a green as any in the deposit. The deeper shades of green seem also to occur nearest the top or surface edges of the beds. Prospecting with a core drill is recommended if more definite knowledge is desired regarding the continuation of green shades in depth. The rock here is not so badly fractured at the surface as along the shore, and it is possible to get out some very good sized blocks without quarrying deeply. A 1-ton block, which was moved on skids down the trail to the beach, has already been shipped to Portland, Oreg. Another opening on this same ledge was noted about 600 feet from the beach and about 200 feet above water. The beds here are banded with dark blue or gray and white near the southwest wall, but the blue bands change to dark green near the middle of the ledge. A small mass of garnet-colored calcite was noted in the rock at this place.

At these various prospects a vigorous growth of timber has had to be cleared away, and a cover ranging from a few inches of moss on the exposed places to soil 6 or 7 feet thick in the crevices and hollows in the rock has had to be stripped off.

Other prospects of the Alaska-Shamrock Marble Co. are situated on this peninsula on the north shore of Dickman Bay and extend up a small bight about three-fourths of a mile from the extremity of the peninsula. The dip and strike and the position of the beds exposed here indicate that they are probably continuations of the ledges exposed near Shamrock Inlet. Diabase dikes have intruded the beds in this locality, and the surface exposures of the stone show much jointing and fracturing. The marble occurs in various shades of white, bluish gray, and green. In polished samples some of the green marble compares favorably with the "verde antique" types produced in the United States. The beds are exposed in bold cliffs on both sides of the small cove and they also form its floor and extend inland beyond the head of the cove. This area was the first one to be prospected by the Alaska Shamrock Marble Co. The prospecting has been done mainly by hand drilling and loosening blocks with black powder. Considerable material has been shipped to Portland for exhibition. Another possible resource of this company is the gray granite that outcrops on the shore of Dickman Bay between the two marble localities.

Though much of the marble available here is of great beauty when finished, the structural conditions suggest the necessity of consider-

able waste in quarrying and in finishing. Much more prospecting and development work must be done in order to ascertain whether or not the properties can be exploited on a commercial basis.

All the properties are situated most favorably for shipping quarry products. Deep water extends practically to the shore line, except in the small cove, and both Dickman Bay and Shamrock Inlet afford roomy and sheltered harbors.

REVILLAGIGEDO ISLAND.

Prospecting for marble on Revillagigedo Island has been carried on at intervals for about 10 years. Little of importance has been done, however, since the survey of the Ketchikan district by F. E. and C. W. Wright, who noted the important features of the marble deposits on this island as follows:[1]

> A well-defined limestone belt traverses the eastern portion of Revillagigedo Island in a northwesterly direction and is exposed in Thorne Arm, Carroll Inlet, and George Inlet. * * * Its widest development is on the north side of George Inlet, near the head, where marble claims known as the Bawden group were located in 1904 (No. 14). The deposit is included in the crystalline schist near the contact with the less-altered slates to the southwest. The marble beds range from 10 to 20 feet in width and are separated by strata of calcareous schist. Their strike is northwest and their dip northeast. The marble is exposed in cliffs near tidewater and is of good quality, being relatively free from fracture and joint cracks, finely crystalline, and from white to gray in color. No large developments have been started on this property.
>
> In Carroll Inlet to the southeast claims have also been located on the same belt, but at this locality the deposit is not so extensive as in George Inlet.

In addition to these claims two groups were noted by the writer in October, 1912, on the east side of George Inlet. One (No. 15) lies 6 to 7 miles due north of the point where George Inlet and Carroll Inlet coalesce, and the other about 2½ miles farther north. Only the shore exposures were visible at these places and no prospects could be found. The rock exposed consists of gray to whitish, medium fine grained schistose marble, interstratified with and intersected by dikes of mica dacite. Nearly as much dike rock as marble is exposed on the beach at the southern locality. All the beach exposures of marble are very soft and saccharoidal, almost too soft to yield a hand specimen. The beds dip about 30° a little north of west. So far as these exposures indicate, little if any commercially valuable marble is present at either place.

HAM ISLAND AND VICINITY.

LOCATION AND GEOLOGIC RELATIONS.

Ham Island lies in Blake Channel at its junction with Bradfield Canal about 25 miles southeast of Wrangell. It is about 1¼ miles long and is composed largely of crystalline limestone interstratified

[1] Wright, F. E. and C. W., op. cit., pp. 197–198.

with beds of calcareous schist. These beds strike N. 35° W. and fall in line with a long lens or belt of crystalline limestone, which begins on the mainland 2 miles southeast of Ham Island and is continued on the mainland about 10 miles to the northwest. According to the Wrights,[1] the metamorphism of the limestone to marble has probably been caused by the intrusion of wide belts of granite both on the mainland and on Wrangell Island.

HAM ISLAND.

The marble beds have been extensively tested on Ham Island, and deposits have been prospected and claims located on the mainland north, east, and southeast of Ham Island. In the northern part of Ham Island (No. 17) the greater part of the marble available is coarse grained and varies in color from light grayish blue to dark gray, but some of it is nearly white. A little fine-grained marble, mostly white, lies in the southeast portion of the island. Two groups of claims on Ham Island, owned originally by Woodbridge & Lowery and by Mr. Miller, have recently been purchased by the Vermont Marble Co. but are not under development by that company. Although the strata have been crumpled and folded and are slightly schistose in places, the stone generally seems sound and the rock is not so badly checked and fractured as in certain other marble areas in southeastern Alaska. Several systems of joint planes intersect the beds, but the joints are spaced widely enough not to interfere greatly with quarrying. The marble occurs in beds of varying thickness, generally 2 to 4 feet or more, that strike northward and dip at an angle of 50° or more toward the east. In the eastern part of the island, south of the middle, the presence of some beds of fine-grained white marble, 20 feet thick, alternating with coarser crystalline marble, has been shown by the core drill. In some places the presence of many veins and nodules of quartz and chert in the white marble has been shown by drilling perpendicular to the bedding, and it is feared that these may present a serious obstacle to the utilization of these beds. The quartz veins are generally from a fraction of an inch to a few inches in thickness, though at least one vein a foot thick has been noted.

MAINLAND NEAR HAM ISLAND.

On the mainland in the vicinity of Ham Island the Vermont Marble Co. holds two claims of 160 acres each about 1 mile east of Ham Island on the north side of Bradfield Canal (No. 18), and two claims 1½ miles southeast of Ham Island on the south side of Bradfield Canal (No. 19). Neither of these properties has been developed.

[1] Wright, F. E. and C. W., op. cit., p. 198.

The occurrence of marble on the mainland northeast of Blake Channel is reported by Frank Spaulding, of Wrangell, who holds five claims of 20 acres each. The deposit is reported to lie southeast of Ahrens Creek (No. 16) and to extend back 2,000 feet from the beach and 300 feet above water level. The marble is reported to be coarsely crystalline, a trifle less coarse than the average of the Ham Island stone, and to comprise both gray and white varieties.

COMMERCIAL CONSIDERATIONS.

DEFINITION OF MARBLE.

Technically, marble is a rock consisting chiefly of crystalline particles of calcite or of dolomite or of both. Commercially, marble includes a wide variety of other rocks that are susceptible of receiving a good polish and are suitable for ornamental work. Dale[1] describes among the commercial marbles of Vermont a serpentine and a chrome-mica schist, and it is interesting to note that some of the most handsome polished samples of marble produced recently in Alaska owe their distinctive banding and coloring to their schistose character.

FACTORS CONTROLLING VALUE.

The value of a marble deposit in southeastern Alaska can not be judged by small surface samples alone, although tests of such samples may be of considerable importance. The character of the deposit as a whole must be considered, or at least so much of it as will be required for a quarry, as well as extent, color, lack of objectionable impurities such as silica, pyrite, argillaceous and organic matter, soundness, absence of fractures or joint planes and of intersecting dikes, facility of quarrying and loading on vessels, distance and freight rates to markets, and competition.

The features that probably will cause the most serious hindrance to profitable quarrying in southeastern Alaska are the fracturing and jointing of the beds. Observations have shown that this is very prevalent at the surface in this region, and such experience in quarrying as has been had has shown that the cracks extend 60 feet or more below the surface. It is, of course, possible that at greater depths sounder stone will be found, but it is not profitable to be obliged to reject a large percentage of waste simply because the percentage of available blocks of the requisite size is limited by the structure of the deposit. The excessive moisture and the influence of the dense vegetation in this region has softened the surface marble, in places to surprising depths as compared with other well-known regions.

The practical judgment of a competent marble quarryman is necessary to decide many of the questions relating to the availability

[1] Dale, T. N., The commercial marbles of western Vermont: U. S. Geol. Survey Bull. 521, pp. 49–50, 1912.

of the stone. Cross trenching, a common form of prospecting to determine the surface extent of a marble deposit, must be supplemented in southeastern Alaska by the core drill. A careful study should be made at the surface of the directions or strikes of the various systems of joints, their minimum, maximum, and average spacing, the direction and angle of their dip, and the nature of the fracturing that is not related to the systematic jointing. A sufficient number of holes should then be drilled to such depth and in such directions that a definite idea may be obtained as to the character of the beds below the surface, especially in relation to fracturing and jointing and the hardness of the marble.

Tests of the cores, including chemical analyses, measurement of size of grain, absorption, porosity, compressive strength, and polish are all of great value, but satisfactory tests for strength and polish may not be practicable unless the core is of a diameter of 2 inches or more.

LOCAL SAWING PLANTS.

Thus far the products of Alaska marble quarries have been confined practically to marble for interior finishing (see p. 76), and, as already mentioned, the percentage of waste in quarrying is necessarily great because it does not pay to ship blocks that can not be almost entirely sawed into large and perfect slabs for polishing. If the marble is of suitable character for exterior construction (and much of it appears to be suitable for such purposes), local sawing plants might produce much dimension marble from blocks that would otherwise be rejected. Small polishing plants might also utilize much of the waste marble by working it up into the smaller slabs required for base boards, tiles, plumbing fixtures, moldings, and the like. A small sawing plant was installed at one quarry, but operations were soon discontinued and no figures are available as to the relative costs of operation in southeastern Alaska and on Puget Sound; it is understood, however, that the high cost of coal in this part of Alaska makes manufacturing generally rather expensive. Moreover, the Puget Sound cities are supplied with relatively cheap electric power.

WATER POWER AND ELECTRICITY.

In southeastern Alaska electricity is generated by water power at seven or more places.[1] It is reported that abundant water power is available on Kosciusko Island near Holbrook, less than 4 miles from the marble quarries on Marble Island. To deliver electric power to Marble and Orr islands a cable would have to be laid across a channel measuring, according to the Coast and Geodetic Survey charts, about

[1] Hoyt, J. C., A water-power reconnaissance in southeastern Alaska: U. S. Geol. Survey Bull. 442, pp. 147–157, 1910. See also Engineering News, pp. 551–553, 1910.

3,400 feet in width and 120 feet in depth; or else a line several miles longer would have to be built around the head of Tokeen Bay. In southeast Prince of Wales Island and on Revillagigedo Island the appearance of certain mountain streams and waterfalls suggests the possibility of power not yet utilized. It should be stated, however, that none of these streams were studied with reference to their source of supply, and that unless fed from natural reservoirs such streams can not always be relied on to furnish power throughout the year.

TRANSPORTATION.

As already mentioned all the properties thus far developed and a great many undeveloped deposits are situated either close to or directly on deep water. At present marble in rough blocks is carried by freight steamers to Tacoma, Portland, and San Francisco. Freight rates have been much reduced in the last few years through competition and are reported to be moderate at present.

COMPETITION.

Considerable marble is still shipped to the Pacific coast from quarries in the eastern United States, mainly Vermont and Tennessee, and some is imported from Italy. The Alaska product is, however, increasing, and it is reported that there is a market for all of it that can be produced. In the western half of the United States marble quarries and prospects have been opened in Stevens County, Wash., Josephine County, Oreg., Inyo and Tuolumne counties, Cal., Cochise County, Ariz., Otero County, N. Mex., White Pine County, Nev., Beaver County, Utah, and Gunnison County, Colo. Only the product of the California and Colorado quarries has been of commercial importance thus far.

In British Columbia large deposits of marble are known along the sounds, on the coast, and in the interior. Among those on Vancouver Island are deposits on Nootka Sound and at Beaver Cove. The deposit on Nootka Sound was once quarried but is reported not to have been operated since 1909. On Malaspina Inlet two small deposits have been noted, one of which is of white marble and the other of gray and white marble, mixed with serpentine.

The principal marble quarry in the province is that of the Canadian Marble & Granite Co., on the Canadian Pacific Railway between Lardo and Trout Lake. This quarry is equipped with finishing works and supplies the greater part of the marble used in British Columbia. White marble is reported near the town of Wycliffe, on the Kimberly branch of the Canadian Pacific Railway, and dolomitic marble of various colors in the Rocky Mountain region on the slopes of Mount Ogden 2 miles from the mouth of Yoho River.

It is not likely that during the maintenance of the present tariff on marble much of the Canadian product can be sold profitably within the United States, nor can the Alaskan product be delivered in Canada, although it must pass through Canadian waters en route to the United States.

PRODUCTION.

The first production of marble recorded by the Survey was made in 1901 by the Alaska Marble Co. from the quarry at Calder, the first shipment to the United States having been made in 1902. For the years 1902 and 1903 no production was reported, but beginning with 1904 the production has steadily increased year by year. It is not possible to give the statistics of production by years, for in only one year were there more than two reporting producers, and it is the Survey's custom to conceal all production not reported by three or more producers. In all, however, from 1901 to 1912 five producers have reported total shipments of unfinished marble to the United States of an approximate value of $400,000. Not included in this total is a small output of marble used locally for tombstones and monuments.

USES.

Small quantities of marble have been shipped to the United States from the quarries of the Alaska, El Capitan, Mission, and Alaska-Shamrock companies, but by far the greater part of the output has come thus far from the quarry of the Vermont Marble Co. on Marble Island. The product of this quarry is shipped to the electrically driven mill owned by the company at Tacoma, Wash., where the rough blocks are sawed into smaller blocks for turning and planing and into slabs three-quarters of an inch to 1 inch thick for polishing. The slabs and sawed blocks are worked up into wainscotings, ceilings, floor tiles, moldings, fixtures, rails, balustrades, and a variety of forms for interior finish and decoration. The market for these products comprises the cities of the Pacific coast States and extends as far eastward as Salt Lake City.

In the following important buildings marble from Tokeen, Alaska, is reported to have been used in interior work:

Buildings having interior decorations of Alaska marble.

SEATTLE, WASH.	TACOMA, WASH.
Hoge Building.	National Realty Building.
Lyons Building.	Perkins Building.
Haight Building.	Tacoma Building.
L. C. Smith Building.	
Bank of California Building.	BELLINGHAM, WASH.
McCormick Hotel.	United States Post Office.

NORTH YAKIMA, WASH.

United States Post Office.

VANCOUVER, B. C.

Pacific Building.
Rogers Building.

PORTLAND, OREG.

Spaulding Building.
Wilcox Building.
Yeon Building.
Selling Building.
Littman-Wolfe Building.
Oregon Journal Building.
Multnomah Hotel.

SAN FRANCISCO, CAL.

Odd Fellows Building.
Sharon Estate Building.

OAKLAND, CAL.

Bankers Investment Building.
Realty Syndicate Building.

SACRAMENTO, CAL.

Forum Building.

LOS ANGELES, CAL.

Los Angeles Investment Building.
Title Insurance and Trust Building.
Van Nuys Building.

SAN DIEGO, CAL.

Spreckels Theater.
United States Post Office.

PRESIDIO, CAL.

United States General Hospital.

BOISE, IDAHO.

State Capitol.
Gem Building.

MOSCOW, IDAHO.

United States Post Office.

LEWISTON, IDAHO.

United States Post Office.

SALT LAKE CITY, UTAH.

Walker Building.
National City Bank Building.
Empress Theater.

It is also reported that this marble was used in the exterior trim in the front of the Merrill Apartments at Seattle, Wash., but that no effort has been made as yet to push the use of the stone for such purposes.

A small quantity of Alaska marble is used locally for monuments, for which it is said to be entirely suitable. A handsome altar in St. Philip's Episcopal Church in Wrangell was fashioned (except the cross) from white marble obtained from Ham Island, Calder, and Tokeen, Alaska. The body of the altar has received a hone finish; the cross, which is of polished Italian marble, is mounted on a base of polished marble from Tokeen. There is apparently no essential difference between these pieces of Italian and Alaskan marble.

THE McKINLEY LAKE DISTRICT.

By THEODORE CHAPIN.

The present report is based on a hasty examination made by J. B. Mertie and the writer in October, 1912. The claims visited are described in some detail because no other account of them has been published recently by the Survey.

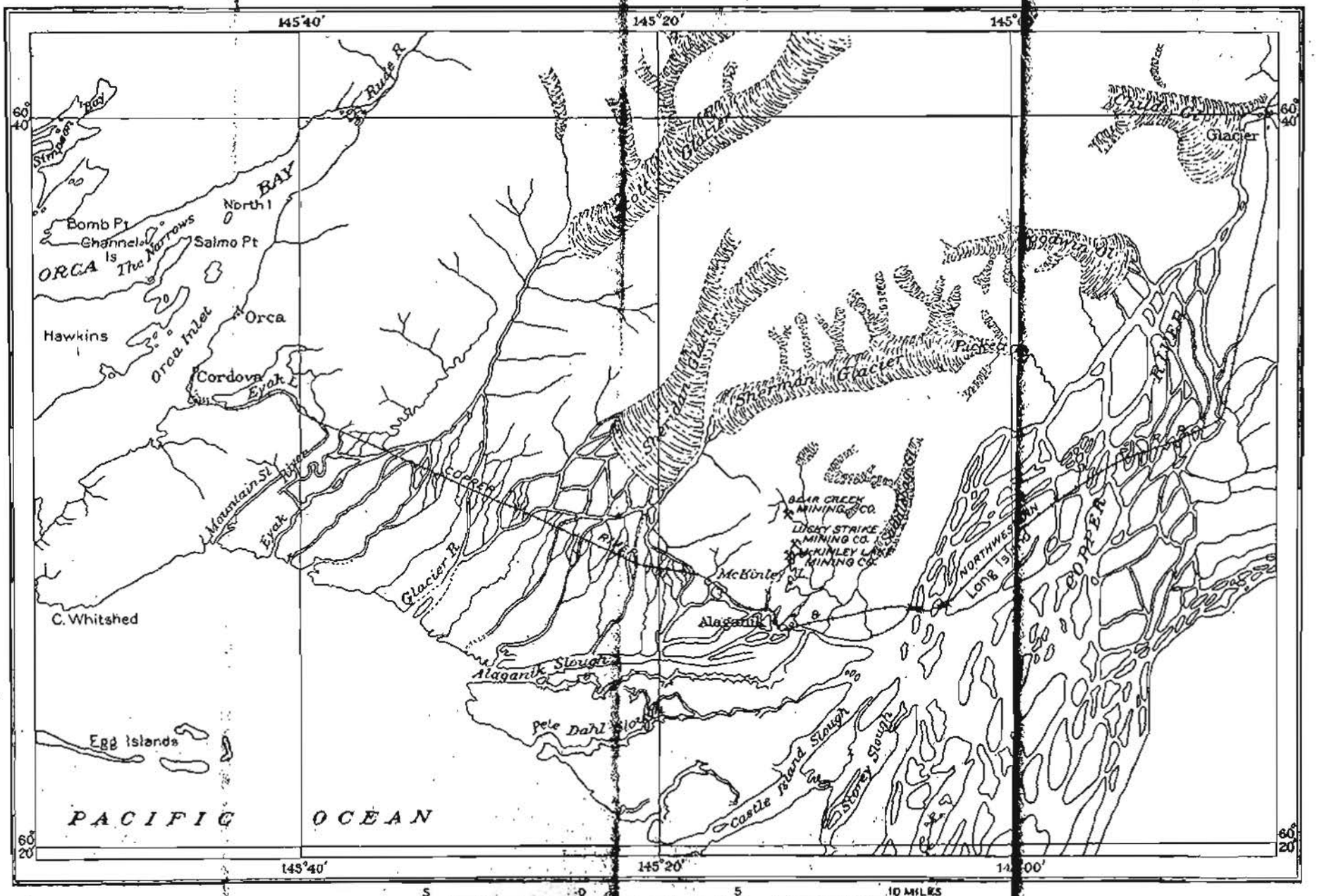
The McKinley Lake properties are situated on the northwest shore of McKinley Lake, a body of water 1½ miles long, which empties into the head of Alaganik Slough, 2 miles from Alaganik and about 20 miles east-southeast of Cordova. (See Pl. III.) They are easily reached by rail from Cordova to Alaganik and thence by a trail 2 miles long. The trail is very swampy but can be traveled by horses in dry weather. The region may also be reached by boat from Alaganik by way of the slough.

McKinley Lake was visited in 1900 by Spencer,[1] who says:

> At this place several veins of quartz have been opened and found to contain gold in varying quantities. A short study of this field was sufficient to show that the principal veins lie parallel to the stratification of the sedimentary rocks and that they usually follow the contact of two beds of different character, as of massive arkose sandstone against shale. In many cases ledges varying in width from a few inches to several feet may be traced for long distances. In one claim the quartz shows a large amount of free gold in small stringers, but this claim has not been sufficiently exploited to determine either the permanency of the vein or its character.
>
> Besides these veins in the planes of stratification there are others transverse to the bedding which have a width up to 4 feet and are known to be continuous for 100 feet or more. One of these which shows no free gold was sampled and found to contain 0.64 ounce of gold. On the whole the Alaganik region seems worthy of the further attention of mining men.

Interbedded slate and graywacke of the Orca group constitute the country rock of the region adjoining McKinley Lake. The dominant strike of the beds is about east and west, and the dip ranges from nearly 0° to about 45° N. The region is cut by a series of gold-bearing quartz veins ranging in thickness from a few inches to 20 feet. These show a tendency to parallel rather than to cut the beds and occur as tabular bodies between the graywacke and slate. The graywacke has been extensively brecciated and subsequently mineralized

[1] Schrader, F. C., and Spencer, A. C., The geology and mineral resources of a portion of the Copper River district, Alaska: U. S. Geol. Survey Special Pub., p. 90, 1901.



SKETCH MAP SHOWING LOCATION OF McKINLEY LAKE DISTRICT.

by an intricate network of quartz veins and veinlets. In the interbedded slate, however, dynamic action has expressed itself in movement along the cleavage planes rather than in the formation of zones of brecciation, and the argillaceous beds are therefore not extensively mineralized.

Small crystals of pyrite and arsenopyrite occur throughout much of the ledge matter, both in the quartz and in the inclosed sediments. Locally the arsenopyrite is very abundant, forming small bodies several centimeters in length and composing a large proportion of the rock. When struck with the hammer it gives off the characteristic garlic odor of arsenic minerals, and it is offensive to the miners who work it. The gold occurs free in the quartz and inclosed in the sulphides, from which it weathers out into little lumps of brown alteration product.

The Lucky Strike Mining Co. has six claims in this region, on which three tunnels with a reported total length of about 400 feet have been driven. Two of the tunnels are on a ledge 20 feet wide, which consists of a brecciated mass of graywacke healed with quartz and carrying considerable amounts of arsenopyrite together with small specks of gold. No samples were collected by the writer, but assay returns from this ledge are reported by the owners to show from $8 to $10 a ton.

The Stringer tunnel follows a well-defined vein with gouge above and below. Vein matter next to the footwall is said to assay $80 to the ton and to have an average value of $15. A mill test on individual stringers of this ledge is reported to have yielded returns as high as $100 a ton. The country rock adjacent to the ledge also contains considerable pyrite and arsenopyrite, with some free gold, and is said to assay about $1.85 a ton.

On the Tiptop claim an open cut has exposed vein matter about 20 feet in width, which cements large brecciated masses of graywacke and slate.

The ledge matter in the main workings of the McKinley Lake Mining Co. is a mass of quartz veins inclosing some blocks of graywacke. On this ledge are two tunnels with an aggregate length of over 600 feet, besides several open cuts. The entire mass is more or less mineralized with pyrite, arsenopyrite, and free gold. The surface outcrop is said to have assayed $100 a ton, and $10 is reported by the owners as an average for the ledge. A small mill was operated on this property for a number of years but was subsequently removed.

The property of the Bear Creek Mining Co. is situated on Bear Creek, a tributary of Salmon Creek, a few miles above McKinley Lake. It was not visited, but the formation and geologic relations as reported are much the same as those on McKinley Lake. The property comprises several claims on which some development work has been

done. Several other properties situated on the lake were not examined but are reported to carry small quantities of gold.

The mining conditions in this area are exceptionally favorable. Excellent timber is abundant and transportation facilities could easily be provided by a railroad branch from Alaganik. The location of the veins on the steep slopes of McKinley Mountain should afford natural dumps and gravity haulage. In 1912 only two men were at work in this region, but the owners of the claims hope to interest outside capitalists in the near future and to open the properties on a larger scale.

MINING IN CHITINA VALLEY.

By FRED H. MOFFIT.

INTRODUCTION.

The gold and copper deposits of Chitina Valley are commonly referred to more or less indefinitely as being in the Copper River region, and this practice has sometimes given rise to the idea that they are situated in the main valley of Copper River. This idea is not wholly correct, as most of them lie, not in the valley of the Copper, but in that of its large eastern branch, Chitina River.

The district has attracted attention from the beginning of active Alaskan exploration and its major geologic and geographic features have been described in various publications.

During the summer of 1912 a detailed investigation of the western part of the copper belt, including Kuskulana and Kotsina rivers, was begun, but owing to the shortness of the field season and to the unusually unfavorable weather conditions, it could not be completed. The topographic mapping done by Mr. Witherspoon included only the upper valley of Kuskulana River and of Strelna Creek, for the working season did not afford time to extend the mapping northward and westward to Kotsina River and Elliott Creek. Geologic mapping was carried on in connection with the topographic work and over practically the same area, except that none was done east of Kuskulana River. Geologic work was begun about the middle of July by T. S. Chapin, who was joined in the middle of September by J. B. Mertie and the writer. Field work was continued till October 1, when it had to be given up because of a lack of feed for the horses.

The work of the season showed that the geologic structure of this part of the copper belt is much more complicated than had been supposed and that sedimentary beds (probably Carboniferous) older than any previously recognized in this vicinity are present. It also disclosed that in this district deposits of copper are associated with diorite intrusives as well as with the greenstones, a fact of importance not generally known.

Geologic conditions throughout the Chitina Valley have been considered to be almost alike, except for the character and occurrence of the ores. The stratigraphic succession throughout most of this

region, beginning with the oldest rocks, includes the Nikolai greenstone, from which most of the copper was derived, the Chitistone limestone (Upper Triassic), the McCarthy shale (Upper Triassic), and the Kennicott formation (Upper Jurassic). The three lower formations follow one another in unbroken succession, but the Kennicott rests unconformably on them. Sedimentary rocks older than any of those mentioned form part of the mountains about Strelna Creek and south of Elliott Creek. Field work has not progressed far enough to determine the area occupied by these rocks, but it is evidently small and does not extend far to the east. It is quite possible, if not probable, however, that some of the rocks on Kotsina River north of Elliott Creek, previously represented on the maps as being of unknown age, may belong among these older beds.

The season of 1912 was unfavorable for mining in the Chitina Valley, on account of the adverse weather conditions. Low temperatures and rain prevailed throughout most of the summer but did little direct damage to mining property till late in the season. Much damage was done to the railroad, however. Early in August the approach to one of the Copper River bridges was carried away and about the middle of September so much damage was done to the tracks by landslides that communication between Cordova and Chitina was interrupted for about six weeks. These difficulties were felt by the copper miners chiefly through shortage of supplies and especially of feed for horses; this shortage became serious by October 1. The floods were felt more directly by the placer miners of the Nizina district, where much damage was done to mining equipment.

COPPER.

The copper prospects on which most of the development work is being carried on lie in two main districts, one centering in the Kennicott-Bonanza mine and the other in the properties on Copper Mountain, at the head of Clear Creek, near the head of Kuskulana River.

Shipment of ore from the Kennicott-Bonanza was begun at the completion of the Copper River & Northwestern Railway in April, 1911, and has continued to the present time. None of the other copper properties in the Copper River basin has yet made commercial shipments of ore, but the increased facilities for mining that came with railroad transportation have stimulated their development, and a large amount of money has been expended for this purpose.

The Great Northern Development Co. has a well-equipped plant on Clear Creek, about 3 miles above its mouth and about 2,900 feet above the flood plain of Kuskulana River. This company has other property on Kotsina River, at Iron Mountain, and near Kennicott,

but most of its development work has been done on its Clear Creek or Copper Mountain property, where approximately 40 or 50 men are employed. No ore has been shipped, but not far from 5,000 feet of tunneling has been driven and considerable ore is blocked out. The copper minerals are chiefly chalcopyrite and cupriferous pyrite, with a small amount of oxidation products, mostly carbonates. The ore is contained in a mass of diorite intruded into the Nikolai greenstone and is also found in the greenstone itself, and it is not yet proved whether it originated in the greenstone or in the diorite.

Electricity for light and for use underground is generated by gasoline power, the gasoline being freighted in over the snow in winter. Work was begun in 1912 on an aerial tramway to connect the mine with a projected spur from the railroad 13 or 14 miles long. Part of the preliminary survey has already been run. Strelna, at "mile 146" on the railroad, is the distributing point for this vicinity. A private telephone from Clear Creek to Strelna was recently completed and thus established communication with Cordova, on the coast.

The Alaska Consolidated Copper Co. is said to own forty-five claims on Nugget Creek, thirty-five of which are patented. Most of the development work has been done on a claim described elsewhere[1] as the Valdez claim. A calcite vein containing bornite and a minor amount of chalcopyrite lies in a fault plane cutting greenstone at this locality. It has a maximum thickness at the surface of 24 feet but shows much variation. The claim has been developed by a shaft 163 feet deep and by approximately 900 feet of tunneling. Much ore has been piled on the dumps or sacked.

The Rarus group of claims, on the southeast side of Kuskulana River, is also being explored by the Alaska Consolidated Copper Co.

The Rarus group is adjoined on the southeast by what is known as "Ole Berg's property." A body of sulphide ore found on this property is considered by the miners to be the most important of the later discoveries in this vicinity. A wagon road is being built along the east side of Kuskulana River to connect the claims with the railroad and provide a means for freighting machinery to them.

The Alaska United Copper Exploration Co. continued work on the Blackstone group of claims on Porcupine Creek during the early part of the season. The Hubbard Elliott Copper Co. reports, besides assessment work on numerous claims, the completion of 118 feet of adit on the Albert Johnson claim, planned to undercut the outcrop of the ore body at a depth of about 500 feet. Preparations have been made to install an air compressor. Assessment work was done by other miners on many claims on Kotsina River and its tributaries, and it is

[1] Moffit, F. H., and Maddren, A. G., Mineral resources of the Kotsina-Chitina region, Alaska: U. S. Geol. Survey Bull. 374, p. 72, 1909.

reported that an ore body of promise is being developed on Chesnina River. Details regarding these developments are lacking.

A very prosperous year is reported from the Kennicott-Bonanza mine, notwithstanding the fact that several unusual obstacles had to be overcome in the course of the work. Not only were the shipment of ore and the receipt of needed supplies interrupted during the later half of the summer by the suspension of railroad traffic, but some difficulty was encountered in operating the mill, owing to the unstable character of the morainal material on which it was erected, and operations had to be suspended till the defect could be remedied.

At least a part of the ore shipped from the Bonanza in the early summer was a concentration product from talus material on the mountain slope below the mine. This accumulation of loose rock fragments contains a large amount of chalcocite broken down from the ore body above and is looked on as an important source of copper. The owners of the Bonanza mine have also gone ahead with the development of the Jumbo chalcocite deposit, which is situated about a mile northwest of the Bonanza mine, and on which a considerable body of ore was in sight at the surface before any work was done.

Other companies operating in the vicinity of Kennicott were engaged in prospecting copper lodes 3 or 4 miles northwest of Kennicott, on the mountain in the middle of Kennicott Glacier, at the Nikolai mine on Nikolai Creek, and on the Mother Lode property northeast of Kennicott. A road constructed along McCarthy Creek for freighting machinery to the Mother Lode camp will also be available for the use of miners on Nikolai Creek, where development of the Nikolai mine has been carried on actively for the last two summers. None of these properties, nor the Westover claim on Dan Creek, are in a position to ship ore.

GOLD.

The Nizina gold placer district includes Dan, Chititu, and Young creeks. Most of the gold produced in this district in former years and also the larger part of the production in 1912 has come from Chititu Creek, though some was contributed by Dan Creek or its tributaries and some by Young Creek. The total production for 1912 is larger than for several previous years in spite of the unusual discouragements brought about by unfavorable weather.

The floods were felt most severely on Dan Creek, where a recently constructed and expensive hydraulic plant was destroyed by the September floods and a large part of the labor of two years was lost. The lower part of Dan Creek lies in a narrow valley where the water has little chance to spread and consequently is particularly liable to do injury in times of unusual flood. The miners on Copper Creek, in the upper part of the Dan Creek basin, escaped with less injury, for less water was concentrated there and the valley is relatively wider.

In the Chititu Creek basin three hydraulic plants were in operation in 1912. One was on the main stream and the other two were on Rex Creek, the northern branch of Chititu Creek. The plant installed on Chititu Creek several years ago was moved in 1911 to a point on Rex Creek not far above its mouth, and in 1912 a new and larger plant was built on Chititu Creek. The third plant in operation is near the head of Rex Creek. These three plants suffered less injury from the September storms than the one on Dan Creek but did not wholly escape. Unfortunately the high water came just before one of the lines of sluice boxes was to be cleaned up and buried everything, including the gold, under a mass of gravel, necessitating much extra work for its recovery. Better weather in the later part of September and early part of October, however, made it possible to work much later than has been customary, and the damage and loss of time had less effect on the season's gold production than they would have had in previous years.

MINERAL DEPOSITS OF THE ELLAMAR DISTRICT.

By S. R. Capps and B. L. Johnson.

INTRODUCTION.

LOCATION AND AREA.

The area considered in this report lies along the northeast shore of Prince William Sound between latitude 60° 48′ and 60° 59′ and longitude 146° 28′ and 146° 52′. The area mapped comprises about 60 square miles of land and includes the shores adjacent to Landlocked, Boulder, Virgin, and Galena bays and the northern portion of Bligh Island (Pl. IV). Although earlier maps of this region showing the shore line and something of the topography are available, they are all on a relatively small scale. The map used for the base of this geologic investigation will be published on a scale of 1 to 62,500, or approximately 1 mile to 1 inch. This map and a more complete report of the geology and mineral resources of the area are now in preparation and will be published later.

PREVIOUS WORK.

The territory adjacent to Prince William Sound is one of the most accessible portions of Alaska. The sound was discovered in 1778 by Capt. James Cook and during the succeeding 16 years was visited by a number of navigators who charted its shores, so that for more than 100 years the major features of this region have been known. Geologic explorations, however, followed much more tardily. Geologists first visited this field in 1898, when Mendenhall[1] reported on the geology of Port Wells and Passage Canal and Schrader[2] examined portions of the shore between Orca and Valdez. In the following year the Harriman Alaska Expedition[3] did considerable geologic work on the sound, and in 1900 Schrader and Spencer[4] visited parts of the region between Orca and Port Valdez. More recently Grant and Higgins[5] prepared a fuller report on reconnaissance work done in 1905, 1908, and 1909.

[1] Mendenhall, W. C., A reconnaissance from Resurrection Bay to Tanana River, Alaska, in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 265-340, 1900.

[2] Schrader, F. C., A reconnaissance of a part of Prince William Sound and the Copper River district, Alaska, in 1898: Idem, pp. 341-423.

[3] Gilbert, G. K., Harriman Alaska Expedition, vol. 4, 1904.

[4] Schrader, F. C., and Spencer, A. C., The geology and mineral resources of a portion of the Copper River district, Alaska: U. S. Geol. Survey Special Pub., 1901.

[5] Grant, U. S., and Higgins, D. F., Geology and mineral resources of Prince William Sound, Alaska: U. S. Geol. Survey Bull. 443, 1910.

OUTLINE OF THE PRESENT INVESTIGATION.

In all of the previous investigations the great area to be covered within a short summer season has prevented the examination in detail of the geology of any particular locality. The steady production of one mine at Ellamar for a number of years and the recent placing of two other mines in Landlocked Bay on a productive basis have singled out the district in the vicinity of Ellamar as an important copper-producing area. It therefore seemed advisable to secure more detailed information about this area, with the hope of clearing up some of the problems concerning the origin and relations of the ore deposits and the geologic succession in the Prince William Sound region. For this purpose a topographic party in charge of R. H. Sargent, assisted by C. E. Giffin, was detailed to map an area including the territory adjacent to Landlocked, Boulder, Virgin, and Galena bays. The writers were assigned to study the areal and economic geology of this same area. Owing to the late date at which the appropriation for this work was made by Congress, the field work was not commenced until August 25, 1912, and the weather forced it to close on October 17. In this short season a topographic map of an area of about 60 square miles was completed and much information obtained concerning the mining developments, the modes of occurrence of ore, and the areal distribution of the various rock formations.

GEOGRAPHY.

SURFACE FEATURES.

The district in the vicinity of Ellamar, as well as all of the Prince William Sound region, is included within the borders of the Chugach Mountain Range. Near Ellamar the highest peak is Copper Mountain, which has an elevation of 3,946 feet. Eight miles northeast of Copper Mountain but outside the area with which this report is concerned Mount Denson, locally known as the "Rooster Comb," reaches a height of 5,886 feet. Farther north, toward the main axis of the range, the peaks become progressively higher, approaching 7,000 feet at the crest of the range. From a distance the peaks of the range seem to have a certain accordance of elevation, which Grant [1] interprets as suggesting an ancient peneplain that has been elevated far above sea level, warped, and eroded. In the area around Ellamar erosion has been so extensive that all suggestions of this peneplain are lacking.

The coast line of this area is very irregular, as is that of the whole of Prince William Sound. The area studied, though comprising only about 60 square miles of land surface, has a coast line 116 miles

[1] Grant, U. S., Geology and mineral resources of Prince William Sound, Alaska: U. S. Geol. Survey Bull. 443, p. 15, 1910.

in length. No part of it is more than 3 miles from tidewater. Notwithstanding the short distance within which any point may be approached by boat, the country in this vicinity is very difficult to traverse. The mountains in most places rise steeply from the shores and are in general densely timbered to an elevation of 1,800 to 2,000 feet. Practically all travel is by boat, and few trails have been cut. There are some less rugged areas, such as those on both sides of the mouths of Landlocked and Galena bays, bordering Tatitlek Narrows, and at the head of Galena Bay, where the timber is in scattered groves, with grassy or marshy openings between, and in these places travel is less difficult.

The irregular and indented shore line gives abundant harbors for small craft, and some of them will admit ocean steamers.

The topography has in places been strongly influenced by the structure of the bedrock, though this influence has in other places been of minor importance. Tatitlek Narrows lies along the strike of an easily eroded slate belt, and Copper and Ellamar mountains are of more resistant greenstone. West Bay, Cloudman Bay, and the head of Galena Bay all lie parallel to the strike of the underlying rocks, as does the shore line east of Graveyard Point. On the other hand, Landlocked Bay and the lower half of Galena Bay cut directly across the strike of the rocks, and in these places other agencies were more powerful than the rock structure in determining the direction of the erosion lines.

STREAMS.

The largest stream in the vicinity of Ellamar is Millard Creek, which enters the head of Galena Bay from the southeast. This creek drains a basin about 9 square miles in area, including two good-sized lakes. It fluctuates in volume, as after each rainfall the run-off is rapid from the steep mountains at the head of the basin, but throughout the summer season a good volume of flow is maintained.

A second large creek empties into the lagoon at the northeast end of Galena Bay. Most of its basin lies outside of the area studied, but it is reported to drain a large lake which is fed by an active glacier.

Two creeks of moderate size enter the head of Landlocked Bay, the larger from the northeast and the smaller from the northwest.

In addition to the above-mentioned streams numerous creeks of smaller size reach the coast at short intervals. Many of these creeks are small and intermittent and flow only after heavy rains. Others are permanent and occupy well-defined though short valleys. The deep indentation of the coast and the high relief of the land have prevented the gathering together of numerous tributaries to form

elaborate drainage systems, as most streams have been able to find a short direct course to the sea.

GLACIATION.

Perhaps the most important single agency which has sculptured the surface of this region to its present form is that of glacial ice. Although there are now no glaciers in the vicinity of Ellamar, other near-by portions of the Prince William Sound region are occupied by vigorous valley glaciers of large size, which are eroding their beds and giving them a characteristic glacial topography. At some time in the not far distant past a great glacier fed by a multitude of valley glacier tributaries filled the Prince William Sound basin and perhaps extended out to sea beyond Hinchinbrook and Montague islands. Near Ellamar the surface of this ice sheet was about 3,000 feet above sea level, for Ellamar Mountain shows glacial scouring and grooving nearly to its top. These grooves were not made by a local glacier which was formed on this mountain but by an ice stream which came from the north and almost if not completely submerged Ellamar Mountain. Copper Mountain also shows glacial erosion to an elevation of at least 3,000 feet. Erosion by this ice sheet was sufficiently strong to shape the mountains up to the highest level to which the ice reached, and its effect upon the lowlands was profound. There fragments of rock, pressed down by the weight of several thousand feet of moving ice, were able to grind away the glacial bed and remove many obstacles to the path of the glacier and to carve out broad troughlike valleys, many of which were excavated far below sea level. Indeed most of the bays and channels of the Prince William Sound region are probably due in an important degree to glacial scour.

At the time when the ice extent was greatest the amount of glacial deepening was more or less independent of the level of the sea beyond the ice edge, so that with the gradual retreat of the glaciers the encroaching sea flooded those parts of the glacier bed which had been eroded below sea level and formed the many irregular bays and channels of the present coast line. Other portions of the rock floor remained at various elevations above the sea. The broad, low pass between Boulder and Galena bays, the low divide between Cloudman and West bays on Bligh Island, and the lowland at the east entrance of Landlocked Bay are portions of the glacier bed which were deepened nearly but not quite to sea level. Landlocked, Boulder, Galena, and West bays and Tatitlek Narrows were deepened below sea level by the ice and were flooded by the sea when the ice withdrew.

It is difficult to reconstruct the drainage system of this region as it was before the period of glaciation, for the ice has done much to destroy the continuity of former stream valleys. It is believed,

however, that the principal valleys, bays, and channels of to-day were the valleys of the earlier streams and that the glaciers, although they profoundly changed the shape of these basins and in many places formed new valleys, have in the main only widened and deepened the valleys of preexisting streams.

TRANSPORTATION.

The district near Ellamar, as compared with most parts of Alaska, is favored with unusually good transportation facilities. As it is bordered by deep water, it can be reached directly by ocean vessels and is on the regular route of the two steamship lines which ply between Seattle and ports on the Gulf of Alaska. During the summer months about one boat a week brings passengers and mail from Seattle, and Ellamar is a regular port of call. In the winter the trips are somewhat less frequent, but even then a satisfactory service is maintained. In addition to the mail and passenger boats several freight boats are kept in service, their schedules depending to some extent upon the amount of ore available for shipment. The regular fare for passengers from Seattle to Prince William Sound ports is $35. The freight rates depend upon the class of freight shipped and the amount of the consignment. Contracts by large shippers of ore from the mines to the smelter at Tacoma have been made at rates as low as $3 a ton.

With such favorable conditions for water transportation practically nothing has been done to facilitate land travel. One road about 4 miles long has been built to a prospect on Copper Mountain from the head of Galena Bay, and one about half a mile long to another prospect from the head of Landlocked Bay, but beyond these no roads have been constructed and but few trails have been made. Practically all communication between the camps is by water.

CLIMATE.

The climate of Ellamar and the immediate vicinity is neither so mild as that of southeastern Alaska nor so cold as that of the interior country. The modifying effects of the Japan current are felt, so that the winter temperature seldom falls many degrees below zero, yet the snowfall is less than on many parts of the coast. Most of the bays remain free from ice all winter, but the head of Galena Bay is said to freeze over at times as a consequence of the considerable quantity of fresh water which flows into it. On the lowlands the snow disappears in the spring in May or early June. The summers are warm and pleasant when the weather is clear, but this is distinctly a rainy country and the majority of days during any summer month may be rainy. No weather records have been kept within this region, but at Orca and Cordova, places having a similar climate, a rainfall of about 191

inches was recorded in 1912. The season of 1912 is reported to have been unusually rainy during the entire summer. Of the 50 days between August 25 and October 13 it rained on 44 days.

VEGETATION.

As a result of the heavy rainfall in this region the vegetation is very dense. Timber grows to elevations of 1,800 to 2,000 feet, except on the steepest mountain slopes and in some of the marshy lowlands. The most valuable stands of timber are found below an elevation of 1,000 feet, in areas of moderate relief. The rock ridges of the higher mountains are without timber, and considerable areas in the lowlands are poorly drained and support only smaller trees in scattered groves, separated by marshy meadows. The most important timber is spruce, of which there are two varieties. Hemlock, however, is more abundant than spruce. Many spruce and hemlock trees have a diameter at the base of more than 4 feet, and these grow tall and free from knots and make excellent lumber. The spruce is considered more valuable for fuel than the hemlock, and near the larger settlements most of the spruce growing near the beach has been cut, but the total amount of timber which has been removed is insignificant compared with that which remains. Below timber line the ground is generally covered with moss, which retains large quantities of water. The untimbered marshy meadows are full of small ponds and the ground is saturated with water. In the timber alder, willow, and other bushy plants grow thickly between the trees, and the spiny devil's-club, familiar throughout the rainy belt of the coast country, is present in abundance. The thick brush, the fallen trees, and the prevailing steep slopes of the mountains make travel through much of the timbered areas slow and laborious, and the mossy covering of the surface renders it difficult for the prospector or geologist to trace the geologic contacts or even to determine the surface formations over considerable areas. Above an elevation of about 2,000 feet, however, there is little timber or other vegetation, and the bare rock is in many places exposed.

GEOLOGY.

CHARACTER OF THE ROCK.

The major features of the geology of the area here considered are shown on Plate IV. As determinable fossils have so far not been found in this vicinity and as two of the rock groups which are here exposed are of almost identical appearance in some of their aspects, it has been found impossible to map all the rocks as definitely as is to be desired. Earlier workers in the Prince William Sound region included the rocks in two great divisions, the Valdez and Orca groups. The Valdez group is older and more metamorphosed, consisting

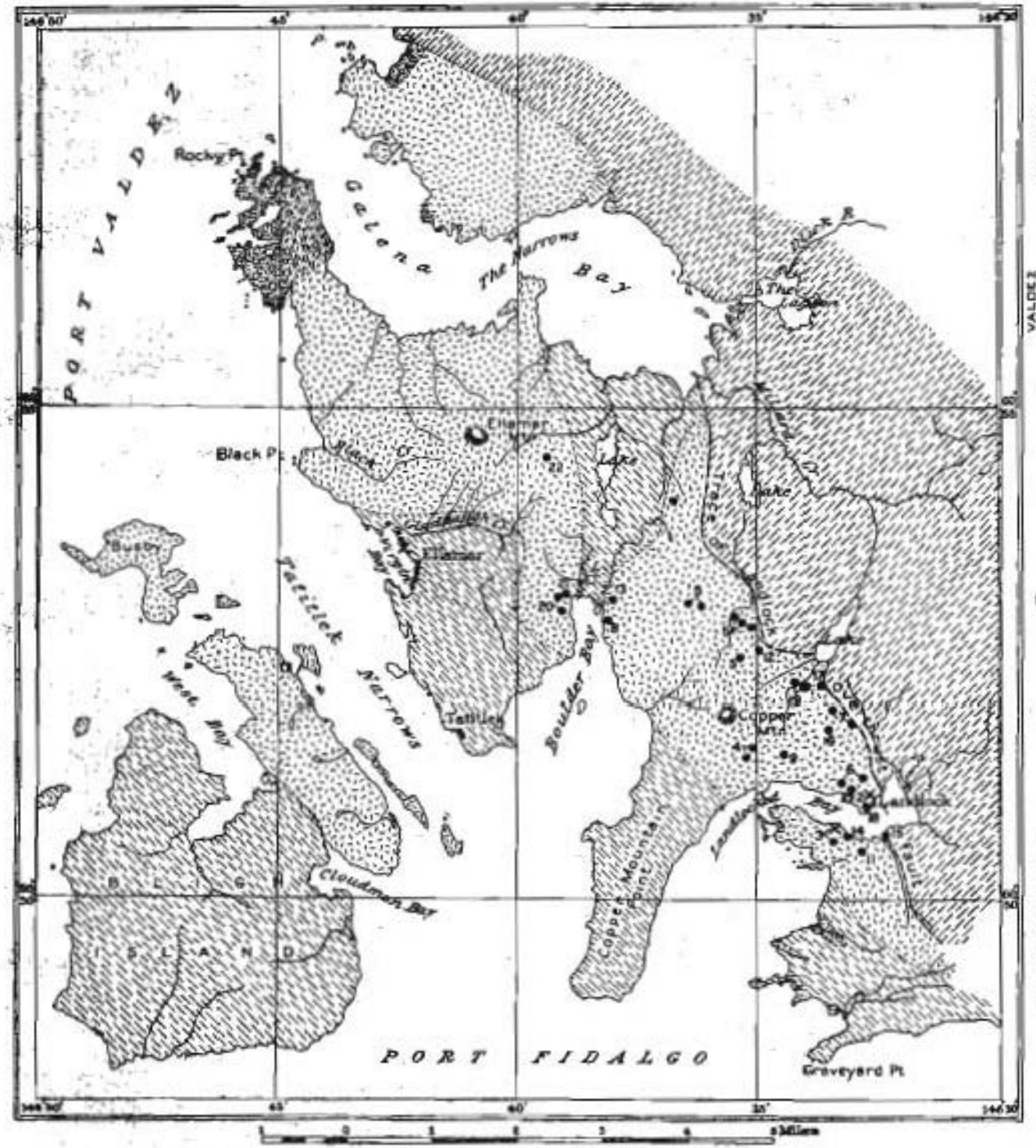
largely of interbedded slates and graywackes. The Orca group is younger and in part consists of interbedded slates and graywackes, though it contains extensive greenstone flows and agglomerates as well as thick conglomerate beds. The criteria which have been used for the separation of the Orca from the Valdez are (1) the lesser amount of metamorphism of the Orca, (2) the presence in the Orca of extensive greenstones and conglomerates, and (3) the geographic position of the Orca to the south of the Valdez rocks, apparently above them stratigraphically. These distinctions no doubt hold for the Prince William Sound region as a whole, but in individual districts, as that with which this report is concerned, extensive faulting accompanied by local metamorphism has taken place and certain areas of slates and graywackes, which are probably of Orca age, have been more intensely metamorphosed than other neighboring areas of the older Valdez rocks. For these reasons the placing of some areas of the slates and graywackes in one group or the other is open to question, and more detailed work will be necessary before a final assignment to a place in the geologic column can be given them.

VALDEZ GROUP.

The oldest rocks shown on the sketch map (Pl. IV) belong to the Valdez group. As described by Grant and Higgins,[1] these rocks consist of slates and graywackes, commonly in alternating bands. They have in some places been recrystallized to form schists. The slates range in color from black to gray, and the cleavage is variously developed. The graywackes consist of angular grains of quartz, feldspars, and other minerals, cemented by a matrix of quartz, muscovite, and chlorite, the whole rock having become somewhat schistose. As shown in Plate IV, the Valdez rocks lie along the north side of the area here considered. They form much of the Chugach Range to the north and are typically developed around Port Valdez and Jack Bay. A short distance north of the mouth of Galena Bay they come into contact with the Orca rocks, the contact having a general northwest-southeast trend. Northeast of Copper Mountain and Landlocked Bay the Valdez rocks appear to have been overthrust upon the greenstones of the Orca group.

As seen within this area the Valdez rocks consist almost entirely of interbedded slates and graywackes containing a few unimportant dikes of later age. The beds in general strike in a northwest-southeast direction and for considerable areas seem to be merely tilted but not much folded. This lack of folding is in many places only apparent, and careful study will often show close, sharp folds with the limbs lying parallel to the general strike of the beds. In

[1] Grant, U. S., and Higgins, D. F., Reconnaissance of Prince William Sound, Alaska: U. S. Geol. Survey Bull. 443, pp. 22-23, 1910.



LEGEND

ORCA GROUP
- Conglomerate
- Greenstone
- Slates and graywackes

VALDEZ GROUP
- Slates and graywackes
- Copper prospect
- Copper mine
- Gold lode prospect

PRODUCING MINES
1. Ellamar Mine
2. Three Man Mining Co
3. Landlock Bay Copper Mining Co.

PROSPECTS
4. Standard Copper Mines Co.
5. Galena Bay Mining Co.
6. S. A. Hemple
7. R. Reynolds-Alaska Development Co.
9, 10, 11, 12. Three Man Mining Co.
13. Fleisher & Hemple
14. T. B. Grove
15. Chisna Consolidated Mines Co.
16. L. P. M. Falck
17, 18. Peter Steinmetz
19. Tibbits
20. Chas. Rua
21. L. W. Wagner
22. A. S. McNaughton, E. H. Turner
23. L. E. Banzer

GEOLOGIC SKETCH MAP OF ELLAMAR DISTRICT.

other places several sets of fairly close folds may be observed, with resulting greater metamorphism. In the neighborhood of Copper Mountain, where the contact between the Valdez rocks and the greenstone of the Orca group is the result of a great thrust fault, the slates and graywackes of the Valdez group have been sheared and fractured. In places the shattered rocks have been filled with quartz in tiny veinlets and as a cement in the graywackes, which in some localities resemble massive quartzites.

The Valdez group, where studied, is remarkably uniform in constitution throughout its thickness, and the lack of recognized key beds makes it difficult to measure a reliable section through the group, as the same beds may be repeated by inconspicuous and easily overlooked faults and folds. It seems certain, however, that the group is many thousand feet thick and is very uniform in appearance throughout.

The age of the rocks of the Valdez group is not yet definitely known, for so far no determinable fossils have been found in them. Various authors at different times have assigned them provisionally to horizons from the Silurian to the Tertiary. A more complete review of the literature on the age and correlation of these rocks will be undertaken in the fuller report on this area which is now in preparation, but for the present it may suffice to state that the Valdez rocks are generally considered to be of Paleozoic age.

ORCA GROUP.

All the consolidated rocks of this area not included in the Valdez group belong to the Orca group. This group is unlike the Valdez in that it consists of a number of characteristic and dissimilar divisions which, though parts of the same great group, can be differentiated and mapped individually in the field. The Orca rocks consist of black slates, interbedded slates and graywackes, greenstone flows and agglomerates, several conglomerate members, and some thin limestone beds. These rocks in general lie south of the rocks of the Valdez group, but the contact wherever seen was a fault contact and the depositional relations between the two groups could not be determined. As already stated, the Orca rocks have been separated from the Valdez on the basis of their lesser degree of metamorphism, the presence of extensive greenstone flows and conglomerate beds, and their geographic position. In using these criteria in the field there has been no hesitancy in assigning the heavy conglomerates on both sides of the mouth of Galena Bay and the thick greenstone flows and tuffs with their interbedded slates to the Orca. The slates and graywackes of Bligh Island are much less metamorphosed than those north of Galena Bay, and they also appear certainly to belong to the Orca group. In regard to the slates and graywackes and thin conglom-

erates of Tatitlek Narrows and on both sides of the mouth of Landlocked Bay there is less certainty, for they have been extensively faulted, folded, and metamorphosed, and on this basis might belong to either great group. In general, however, the authors have agreed with the mapping of Grant and Higgins and placed these rocks provisionally in the Orca group. They contain a number of conglomeratic beds which are exposed for short distances along the beach. These conglomerates are altogether different in character from those at Rocky Point and may indicate considerable interruptions in the deposition of the sediments of which the slates and graywackes are formed, but at present too little is known about them to determine their extent or importance.

As far as could be determined, the lowest part of the Orca group near Ellamar consists of a thick division composed of black slates, which reach their greatest development on Bidarky Point and on the north side of Tatitlek Narrows near Tatitlek (Pl. IV). This division is characterized by its freedom from graywacke beds, those found being thin and forming only a very small proportion of the whole thickness. The slates are predominantly black or dark gray and have a well-developed cleavage, which strikes in a northwest-southeast direction and in most places has steep dips. The bedding is inconspicuous but in places could be distinguished as a banding, the adjacent bands having slightly different colors on weathered surfaces. The bedding is less regular in strike and dip than the cleavage but commonly strikes parallel to it and dips at a greater or less angle to the northeast. The regularity of the strike and dip of the cleavage is confusing and care must be exercised to distinguish between the prominent cleavage and the bedding, which is determinable with difficulty.

Structurally above the black slates is a division composed of slates and graywackes, which closely resemble in constitution and structure those of the Valdez group and which in places may have been confused with them. This division appears in certain localities, as on upper Gladhaugh Creek, to be little metamorphosed and merely tilted, with no apparent close folding. In other places, such as the beach near Graveyard Point, the beds stand on edge and have been closely and intricately folded. This division is believed to extend upward to the base of the greenstone but in places is missing between the black slate member and the greenstone.

Above the slates and graywackes is a thick division composed of greenstone flows and some agglomerates, with minor quantities of interbedded slates (Pl. IV). In physical appearance specimens collected from different parts of the greenstone division may differ widely, ranging from aphanitic, cherty-looking rocks to those of granular texture. Some beds are rather massive, but the characteristic

feature of the greenstones is the abundance of beds in which the greenstone consists of ellipsoidal forms. Ellipsoidal greenstones have generally been considered to indicate that the basic lava flows from which they were formed were poured out upon the bottom of a body of water, and that the flowing and cooling of the lavas under water induced this unusual type of parting into ellipsoidal or spheroidal forms. Many facts which can not be discussed here point to the conclusion that these greenstones were extruded upon the sea bottom, and that the deposition of the muds which formed the slates continued during the intermissions between the separate flows.

Toward the top of the greenstone division, as seen near Rocky Point, the proportion of interbedded slate increases and thin conglomerates appear. In ascending order the conglomerates increase in importance, until the greenstones and slates disappear and a massive coarse conglomerate, with some finer gritty beds, extends to the west end of the point and forms the many small outlying islands. The conglomerate is conspicuous for the lack of assortment of its materials. Bowlders several feet in diameter are not uncommon, and these are intermingled with smaller pebbles and finer material. Bedding planes are indistinct or lacking in many places, and the angular or subangular character of the included bowlders give the deposit an appearance resembling that of a tillite. At other places the unstratified beds are associated with and grade into beds of assorted pebbles and gritty sandstones in which the bedding is distinct. The included bowlders consist mainly of graywackes and banded slates, with scattered greenstones and some granular crystalline rocks.

A mass of similar conglomerate occurs about a mile north of the mouth of Galena Bay and is believed to be a part of the conglomerate just described, though its structural relations to the greenstones are not so clear as near Rocky Point.

What is believed to be the youngest division of the Orca group, as developed in the area under discussion, forms that part of Bligh Island which lies southwest of Cloudman and Busby bays. This division is composed of alternating beds of black or gray slates and graywackes.

The graywacke beds are thicker and constitute a greater proportion of the rocks than in the older Orca group, which has already been described, but the most important difference is that the rocks of Bligh Island, although gently folded and containing some faults, are much less severely metamorphosed. The only rocks with which the slates and graywackes of Bligh Island come into contact are the greenstones on the north side of that island, and this is probably a fault contact. On account of their comparative freedom from metamorphism these beds are believed to be younger than the

conglomerates at Rocky Point and therefore to form the top of the Orca group as developed in this vicinity.

UNCONSOLIDATED DEPOSITS.

No consolidated rocks younger than the Orca occur in this vicinity. The only younger deposits consist of unconsolidated glacial materials, a small amount of talus, and the sands and gravels of the present streams. This area was as a whole one of glacial erosion rather than of deposition, and most of the material removed by the ice was carried to the south and deposited in the sea. In some places, however, there are deposits of glacial till left by the ice during its retreat. The till is found especially in the lowland areas of slight relief. In the more rugged mountains it was either never deposited or has since been removed by erosion. The till areas in general are heavily covered with vegetation, so that good exposures are scarce. The best exposures are at points on the beach where wave cutting is active, such as the southeast side of Bidarky Point. There cliffs show 30 feet or more of bluish clay, inclosing bowlders and fragments of a large variety of rocks. A till mantle covers the surface of the underlying rocks on the lowlands north of Graveyard Point, near Tatitlek and Ellamar, east of the head of Galena Bay, and at many other places.

The gravels of the present streams are of small surface extent and are unimportant. The amount of erosion by streams since the retreat of the glacier uncovered this area is very small, and only a few streams have been able to cut well-defined channels into the rock. The larger streams have naturally been able to erode most vigorously, but the steepness of their gradients has prevented the accumulation of extensive gravel deposits along their courses, and the amount of material handled by them can best be estimated by the size of their delta deposits. Thus Millard Creek, although remarkably free from gravels along its channels, has built out a rather extensive delta at the east end of Galena Bay. The head of Landlocked Bay is also shallow, owing in part at least to the sediments brought down from two good-sized creeks. The greater number of streams, however, are small and empty into tidewater on exposed portions of the coast, at places where the action of waves and currents has carried away the stream-brought materials as fast as they were deposited.

THE ORE DEPOSITS.

RELATION OF THE ELLAMAR DISTRICT TO THE PRINCE WILLIAM SOUND COPPER DISTRICT.

The copper deposits of the Prince William Sound district fall geographically into three large groups—(1) those of Latouche, Elrington, Bainbridge, and Knight islands, (2) those of Glacier

Island and the mainland to the northwest, and (3) those of the mainland along the eastern shore of the sound from Valdez Narrows to Copper River. The Ellamar copper district, as considered in this report, is a small area in the northeast part of Prince William Sound and within the third group outlined above. As already pointed out (p. 87), it is of economic interest because it contains three producing copper mines. Purely scientific interest naturally centers here in a search for the causes which resulted in the localization within this portion of the Prince William Sound copper belt of bodies of sulphide copper ores of sufficient size to be economically important.

DISTRIBUTION OF DEPOSITS WITHIN THE ELLAMAR DISTRICT.

AREAL DISTRIBUTION.

The numerous copper deposits thus far found during the extensive prospecting which has been carried on in the district all lie within the area bounded by Port Fidalgo, Tatitlek Narrows, Galena Bay, and a line connecting the heads of Galena, Landlocked, and Fish bays. The mineralized belt trends in general northwest and southeast, but within the area outlined above there is a marked grouping of the prospects on the flanks of Copper Mountain and along the ridge between Millard Creek and the Galena Bay-Boulder Bay gap. The Ellamar mine, on Virgin Bay, occupies an isolated position, quite apart from the other known copper deposits.

VERTICAL DISTRIBUTION.

The known vertical range of the copper-bearing lodes is over 3,000 feet. The relief within this district is but 3,860 feet and copper prospects are distributed through nearly the entire range of elevation from sea level to places high on the flanks of Copper Mountain, and at Ellamar the mineralization has been traced nearly 600 feet below sea level. Several prospects have been located on Copper Mountain between elevations of 1,500 and 2,500 feet, and copper showings are reported at still greater heights on this peak.

DISTRIBUTION OF PRODUCTIVE MINES.

The productive mines of the area are located at or close to sea level on Virgin and Landlocked bays. The producing mines in 1912 were the Ellamar mine at Ellamar, on Virgin Bay, and the mines of the Three Man Mining Co. and the Landlock Bay Copper Mining Co., on Landlocked Bay (Pl. IV).

GEOLOGIC RELATIONS OF THE ORE DEPOSITS.

GENERAL FEATURES.

The geographic distribution of the ore deposits of the Ellamar district is the result of a combination of definite geologic conditions, partly structural and partly geochemical. The ore bodies are apparently impregnation and replacement deposits of sulphide ores. The channels necessary for the circulation of the mineralizing solutions were furnished by the numerous faults which traverse the area, and favorable conditions for the deposition of the metallic sulphides contained in the mineralizing solutions were supplied by the crushed filling of the greenstone shear zones and by certain sheared and shattered sedimentary beds (slates and graywackes) of the Orca group.

STRUCTURAL RELATIONS OF THE ORE DEPOSITS.

The area is complexly faulted and the distribution and relationships of the various formations shown on Plate IV are largely the result of this faulting. The major fault of the area is the Landlock overthrust, the trace of which within the area mapped extends from the divide between Landlocked Bay and Fish Bay to Valdez Arm across the heads of Landlocked and Galena bays. By this fault the slates and graywackes of the Valdez group have been overthrust from the northeast upon the younger and less metamorphosed Orca group of interbedded slate, argillite, graywacke, conglomerate, and greenstone. During the dynamo-metamorphism of the district the thin-bedded slates and graywackes of both groups were closely folded. The more massive argillites and graywackes and the greenstones of the Orca group, however, yielded by fracturing and were extensively sheared and faulted. This shearing and shattering of the Orca group is observable over a wide area bordering the trace of the Landlock overthrust fault on the eastern slope of Copper Mountain, on the ridge between Millard Creek and the gap between Galena Bay and Boulder Bay, and on the northeast slope of Ellamar Mountain.

Faulting is prevalent in other parts of the area. One large shear zone is found on the southeast shore of Landlocked Bay near the lower end of the bay; another underlies the Ellamar ore body on Virgin Bay. Numerous shear zones visible on the north and south flanks of Copper Mountain are traceable over considerable distances as shallow troughs where erosion has removed some of the soft sheared material. Topographic and geologic evidence suggests the presence of many faults whose contacts can not be definitely located because of the extensive cover of vegetation. As an example may be cited the probable fault between West and Cloudman bays on Bligh Island, which separates the greenstone series of the eastern

peninsula from the gently folded slates and graywackes of the main part of the island.

Two fairly well defined systems of shearing and faulting are recognizable, one system striking a little east of northeast, whereas the strikes of the other trend west-northwest.[1] The latter system of fissuring, paralleling in a general way the strike of the Landlock overthrust fault, is the more prominent and contains the larger number of shear zones and faults. The dips of the fractures of both systems are steep, generally from 55° to 90°.

The copper deposits are abundant in the highly faulted and sheared portions of the area bordering the overthrust fault; none are known in the comparatively little disturbed sections, such as Bligh Island and the region between Gladhaugh Creek and Galena Bay.

RELATION OF THE ORE DEPOSITS TO THE COUNTRY ROCK.

The ore deposits occur in both igneous and sedimentary rocks of the Orca group. They are chiefly associated with the basic lavas (greenstones) but are not entirely restricted to them, as is evident at Ellamar, where the sulphide ores are found in sedimentary beds.

Within the greenstone area the copper lodes are most abundant in the more highly sheared portions. The intense shearing produced numerous passages which afforded easy access to the mineralizing solutions and the crushed filling of the shear zones exposed far greater surface in proportion to its mass than that afforded by the less shattered portions. It was consequently more susceptible to chemical attack by the mineralizing solutions and was replaced by the sulphides with greater readiness than the more massive rock.

Within the areas of sedimentary rocks conditions appear to have been less favorable for the deposition of the sulphides from solutions of the character of those circulating through the rocks at the time the mineralization of the area took place. No copper prospects have been found within the conglomerate areas, within the slate and graywacke areas of Bligh Island, or within the black slate belts of the mainland. It is only at Ellamar, where calcareous strata, interbedded with the slates and graywackes, have been sheared and shattered, that solid sulphide ore bodies have yet been located.

The argillites and graywackes bordering the trace of the great Landlock overthrust fault have been minutely shattered over a considerable area and the fractures filled with tiny reticulating mineralized quartz veinlets, in which, however, the sulphides are widely scattered. Several prospects have been located on deposits of this type but have not been proved to be of commercial importance. The similarly shattered areas in the greenstones of the north spur of Copper Mountain are more highly mineralized.

[1] All bearings given in this report are corrected for magnetic variation.

CHARACTER OF THE ORE DEPOSITS.

The economically important ore bodies of this district, classified as to metallic content, are copper deposits. The ore bodies appear to be impregnation and replacement deposits of sulphide ores, generally in shear zones in the greenstone or, as at Ellamar, in sedimentary beds. Only two sharply defined quartz-filled fissure veins have been noted, and one of these changes along its strike to a mineralized shear zone that carries considerable sulphides and but little quartz. Large masses of low-grade ores are found on the north and east slopes of Copper Mountain, where the Orca rocks bordering the trace of the Landlock overthrust fault were minutely shattered by the faulting. In the argillites and graywackes the fractures were cemented by tiny reticulating mineralized quartz veins with little sulphide replacement of the country rock. Within similarly shattered greenstones, however, a certain amount of metallization of the wall rock occurred together with the cementation of the fractures by the quartz veinlets. Considerable areas were thus slightly mineralized. These bodies of low-grade copper ores in the minutely shattered greenstone areas on the northeast slope of Copper Mountain are not profitably workable under existing conditions but will undoubtedly prove a source of copper at some future time.

The Ellamar type is represented by but one example, the ore body of the Ellamar mine, which, however, is the largest body of massive sulphide ore yet found in this district. Erosion has removed the upper portion of the ore body, but the greatest horizontal dimension of the ore lens appears to have been on the 200-foot level, where the major axis of the elliptical cross section is about 240 feet and the minor axis 90 feet in length. The ore body pinches out between the 500 and 600 foot levels. As no other deposits of this type are known within this district, no definite conclusions can be drawn regarding the probable sizes of this type of ore body should other deposits of similar origin be found later.

The greenstone shear zone type of copper deposit is by far the more numerous, and most of the prospects in this area have been located on deposits of this character. The width of the greenstone shear zones varies from a few inches to several feet. The exact width, however, is in many places hard to determine because of cover, lack of sharp boundaries between sheared and unsheared rock, or the inclusion of horses of unsheared rock within the shear zone. Many of the shear zones are of considerable length. The metallization within the shear zone varies vertically, laterally, and along the strike. Masses of nearly solid sulphides, lenticular both in plan and section, are irregularly distributed within the sheared material. Other portions of the zones are less completely replaced. The size of these massive sul-

phide lenses appears to be restricted in this type of deposit not only by the width of the shear zone but also by the amount of crushing which the material of the shear zone has undergone previous to the introduction of the sulphides. The more highly crushed material is the more completely replaced.

Development work on the shear zones has not yet outlined many large sulphide lenses. The width of the known lenses ranges from mere films to several feet, but at most of the prospects thicknesses of more than 5 feet are not common. The maximum width reported is 9½ feet on an ore body, largely sulphides, the maximum stope length of which as developed is about 60 feet and that portion of the pitch length of the ore body now exposed is about 200 feet. The smaller lenses are much more common.

Because of the nearly vertical position of the shear zones it naturally follows that the lodes of the greenstone shear zone type of deposit are also nearly vertical. Their strikes also correspond with those of the containing shear zones. Many of the ore lenses, however, pitch steeply within the plane of the shear zone.

The intense glacial scouring to which all of this district has been subjected has exposed the primary ore bodies at the surface. Any preglacial enriched zones or weathered parts of the lodes which may once have existed were removed by the glaciation, the recentness of which has moreover afforded little opportunity for surface alteration of the ore deposits. Recent weathering has extended a few inches to a few feet below the surface and in most places the alteration is only partly complete. There is thus no considerable leached zone in the upper portions of the lodes and consequently no enriched zones. Though chemical agents have altered the deposits but little, physical processes have been more active. The soft filling of the shear zones is readily removed by the degradational agents and the shallow troughs formed are traceable over considerable distances.

THE ORE MINERALS.

The primary metallic minerals found in the copper deposits of the Ellamar district are chalcopyrite, pyrrhotite, pyrite, sphalerite, arsenopyrite, galena, gold, silver, and an unknown mineral, presumably a copper-iron sulphide, which is found intimately associated with chalcopyrite on the property of the Three Man Mining Co. on Landlocked Bay. Galena is found in small amounts at some of the prospects about Landlocked Bay, and assays of ore from the Ellamar mine show the presence of lead, probably present as the sulphide, galena. Chalcopyrite is the principal copper-bearing mineral of the district and is found at all of the copper prospects. It is usually intimately intermixed with pyrrhotite, the relative propor-

tions of these two minerals varying greatly. Sphalerite is abundant at Ellamar and at prospects on the north slope of Copper Mountain.

Polished specimens of these ores studied under the metallographic microscope show an early deposition of pyrite, followed by the deposition of chalcopyrite, pyrrhotite, and sphalerite, partly at the expense of the pyrite, which was not stable in the presence of the later copper-bearing solutions. These later sulphides appear to have been deposited contemporaneously. In ore from one of the deposits a soft pale brass-yellow mineral occurs intergrown with the chalcopyrite. This mineral has not yet been determined. It is possibly a new species, apparently a copper-iron sulphide with a low copper content.

Secondary copper minerals are of little importance in this district. Green malachite stains are visible at many prospects and native copper has been found at the property of the Three Man Mining Co. on Landlocked Bay.

The nonmetallic gangue minerals include quartz, calcite, epidote, and chlorite and other minerals derived from the shearing and hydrothermal alteration of the greenstone and other country rocks of the ore deposits.

SUMMARY AND CONCLUSIONS.

The study of the data obtained during the field season of 1912 has resulted in conclusions regarding the distribution and genesis of the copper deposits of the Ellamar district considerably at variance with those of earlier investigators. The data upon which these conclusions are based, however, can not be presented in detail within the limits of this preliminary report, but the evidence at hand appears to warrant the conclusions as now stated, and a more complete discussion of the distribution and genesis of the ore bodies will be included in the final report now in preparation.

Abstract of the geology.—The Orca group of interbedded slates, argillites, graywackes, conglomerates, and basic lava flows was folded and faulted in Mesozoic time, apparently at a considerable depth below the surface, and the Valdez group was overthrust from the northeast upon the Orca. Though no granitic intrusives are found within the Ellamar district, the presence of "knots" at the head of Landlocked Bay is suggestive of their nearness to the surface, and a large granite mass is known to be intrusive into the Orca rocks between Port Gravina and Sheep Bay.

Distribution of the metallization.—The Ellamar copper district is a portion of the Prince William Sound copper district. In the Ellamar district the mineralized area is definitely outlined. The ore bodies all lie west of the trace of the Landlock overthrust fault and east of Tatitlek Narrows. North of Ellamar Mountain the slightly deformed

Orca group is not known to contain any copper deposits. South of Landlocked Bay the copper belt is narrowed by the overlapping Valdez group, but it extends beyond the divide between Landlocked Bay and Fish Bay toward Port Fidalgo. A marked concentration of the deposits is noticeable in the highly faulted and sheared strip bordering the trace of the great overthrust fault. The present known vertical range of the metallization is over 3,000 feet. Structurally the ore bodies occur only in close association with faults and are most abundant in areas of the most intensely localized faulting and shearing.

Time of metallization.—The metallization of the Orca group probably took place in Mesozoic time, subsequent to the folding and faulting referred to above and presumably somewhat later than the intrusion of the granitic rocks of the Prince William Sound region, which probably took place at some time during the Jurassic or Cretaceous. There was but one period of metallization.

Character of the ore deposits.—The studies so far made appear to the writers to indicate that the important ore bodies are primary impregnation and replacement deposits by sulphides of (1) the crushed filling of shear zones in greenstone and (2) certain sheared and shattered sedimentary rocks, presumably those of a calcareous character. The deposits of the greenstone shear zone type are the most abundant.

Attitude of the ore bodies.—The ore bodies occupy or are related to two well-marked systems of shearing and faulting, one system striking east-northeast and the other west-northwest. The dips of both systems are steep, generally from 55° to 90°. There has been no marked metamorphism of the rocks or ore bodies, as the ores and the deposits stand in the positions in which they were originally formed.

Mineralogy of the ores.—The primary metallic minerals of the ores are chalcopyrite, pyrrhotite, pyrite, sphalerite, arsenopyrite, galena, gold, silver, and an undetermined mineral, apparently a copper-iron sulphide. Chalcopyrite is the principal copper-bearing mineral. The association of the metallic minerals is the same as that found in the gold quartz veins of the surrounding regions. The gangue minerals include quartz, calcite, epidote, chlorite, and other alteration minerals.

Character of the metallizing solutions.—The association of metallic minerals in these copper ores is that characteristic of ore bodies of deep-seated origin deposited by alkaline solutions [1] under conditions of moderately high temperature and pressure, at a depth of several thousand feet below the surface.[2] Such hot alkaline solutions are usually ascending waters.

[1] Allen, E. T., and Crenshaw, J. L., Sulphides of zinc, cadmium, and mercury; their crystalline forms and genetic conditions: Am. Jour. Sci., 4th ser., vol. 34, pp. 341-396, 1912.

[2] Lindgren, Waldemar, The relation of ore deposition to physical conditions: Econ. Geology, vol. 2, pp. 105-127, 1907.

Source of the metallizing solutions.—The metallizing heated alkaline solutions were presumably of magmatic origin and probably circulated shortly after the intrusion of the Mesozoic granitic rocks. This conclusion was suggested by the results of the field work of 1912 but can not be considered as proved because of the small portion of the Prince William Sound copper district examined and the lack of granitic intrusives closely associated with the copper deposits in the Ellamar district.

Course of the ore solutions.—The ore-bearing solutions apparently circulated in the channels furnished by faults and shear zones and penetrated but little into the massive rock. The larger faults were naturally the main passageways for these solutions. They appear to have risen principally along the Landlock overthrust and associated large faults and circulated through a group of rocks containing crushed and shattered calcareous beds and greenstone.

Source of the copper and other minerals.—Earlier writers have concluded that the copper deposits of this district were formed either by the concentration of disseminated copper minerals of the greenstones [1] or in connection with the intrusion of basic igneous rocks.[2] An alternative and to the present writers an apparently more probable hypothesis accounts for the presence of the ore minerals—chalcopyrite, pyrite, pyrrhotite, sphalerite, galena, arsenopyrite, gold, and silver—by assuming that they were introduced by magmatic waters, which rose after the cessation of the Mesozoic granitic intrusive activity along the major faults and shear zones and which impregnated and replaced the sheared and crushed greenstones and certain of the sedimentary beds. The metallic mineral association of these copper ores is, moreover, similar to that of the gold quartz veins of the Pacific coast belt of Alaska, which are generally believed to have been formed by deep-seated deposition from magmatic waters, which followed the Mesozoic granitic intrusions. The greater abundance of the copper deposits in the greenstone than in the sedimentary areas appears to be best explained by the more ready replacement of the crushed filling of the greenstone shear zones than of most of the sedimentary beds.

Continuity of the metallization in depth.—The continuity of the metallization in depth is dependent upon the existence of material capable of impregnation and replacement, either shattered calcareous sediments or sheared greenstone, in the path of the mineralizing solutions. The deep-seated origin of the ore deposits, their probable deposition from ascending heated waters, the character of the min-

[1] Grant, U. S., Copper and other mineral resources of Prince William Sound: U. S. Geol. Survey Bull. 287, p. 81, 1911.

[2] Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: U. S. Geol. Survey Bull. 443, p. 58, 1910. Brooks, A. H., Geologic features of Alaskan metalliferous lodes: U. S. Geol. Survey Bull. 480, p. 82, 1911.

eralization, and the known extensive vertical range of cupriferous metallization above sea level are all indicative of the persistence of the metallization to considerable depths, provided the material capable of being impregnated and replaced lay within the path of the rising solutions.

Enrichment.—Enriched copper deposits of economic importance are not found within this district.

Relation of the ore deposits of the Ellamar district to metallogenetic epochs and provinces.—Classified as to age the copper deposits of the Ellamar district probably belong in the late Mesozoic metallogenetic epoch as established by Lindgren. They form, moreover, a part of the metallogenetic province of which gold is primarily and copper secondarily the characteristic metal, associated with the petrographic province characterized by the intermediate quartz monzonite or granodiorite magmas of the great batholith of the Pacific coast, the intrusion of which in late Mesozoic time was immediately followed by intense metallization along its borders. These copper deposits appear to correspond, therefore, in both age and genetic relations with most of Alaska's gold lode deposits and with certain of the copper deposits and belong to the same metallogenetic epoch and province as those of the western coast of the United States.

MINES.

Comparatively little development work has been done, except at the mines now producing, since the region was visited by Grant in 1909.[1]

The writers are indebted to Mr. L. L. Middlekamp, Mr. W. A. Dickey, and Mr. W. A. Rystrom for information furnished and for permission to examine the workings of the mines of the Ellamar Mining Co., Three Man Mining Co., and Landlock Bay Copper Mines Co., respectively. The writers' thanks are also due to Messrs. Peter Steinmetz, Guy Banta, W. B. Hancock, and George Walentine, who acted as guides and furnished considerable information regarding the prospects. The absence of anyone familiar with the underground development at many of the prospects prevented as complete a study of the deposits as might otherwise have been possible. The producing mines are arranged in order of their present importance as producers. The prospects are described in geographic order from north to south.

ELLAMAR MINE.

Location of property.—The Ellamar mine is situated at the town of Ellamar, on the east shore of Virgin Bay, about 20 miles southwest of Valdez. The ore body outcrops on the beach between high

[1] Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: U. S. Geol. Survey Bull. 443, 1910.

and low tide marks. The workings are on the Copper King and Gladhaugh claims, the original discovery being on the end line between these two claims, which were staked along the lead.

History and development.—The Gladhaugh and Copper King claims were located early in 1897 by M. O. Gladhaugh and C. Peterson. The first shipment, of about 225 tons of ore blasted from the outcrop of the ore body, was made late in the fall of 1900. The sinking of the shaft was started in that year, about 150 feet landward from the outcrop of the ore body. The following year the Ellamar Mining Co. was formed. In 1902 a crosscut was driven from the shaft and the ore body was hit on the 100-foot level. In 1905 the shaft had reached a depth of 500 feet and the 500-foot level had been opened, but the ore body had not been found on that level. By 1908 it was known that the ore body pinched out before reaching the 600-foot level. The cofferdam was started in 1909 to exclude the tides from the outcrop of the ore body, so that the portion of the ore body between the 100-foot level and the surface could be removed. In 1910 the cofferdam was completed and since then all the mining has been done between the 200-foot level and the surface. The workings at present comprise a large glory hole, a 600-foot three-compartment vertical shaft, and about 4,000 feet of drifts. In 1912 the lower levels were flooded, and the water stood several feet deep on the station at the 400-foot level. The mine has been a regular producer since 1900.

Equipment and ore treatment.—The mine is equipped with steam plant, air compressor, and drills. Its buildings include machine shop, laboratory, store, smithy, mess house, large ore bunkers, and several other buildings. A large wharf extends from the ore bunkers across the glory hole and out into the bay. The plant is electrically lighted. The average number of men employed in 1912 was 25, working one eight-hour shift a day.

The present method of ore treatment is as follows: The ore mined from the glory hole and stopes falls to the 300-foot level, where it is trammed to the shaft, raised, partly hand sorted, stored in the ore bunkers, and finally shipped to the Tacoma smelter. The cost of mining is reported to average $3 a ton. The transportation charges from Ellamar to the Tacoma smelter are also $3 a ton.

Country rock.—Bedrock outcrops are scarce near the ore body. To the north, south, and east are till-covered flats, and to the west Virgin Bay. All the bedrock to be seen at present is inclosed by the cofferdam, except at extreme low tide, when small additional exposures are visible just outside of the cofferdam along the strike of the ore body. The country rock of the ore deposit consists of interbedded soft black slate, black limestone, argillite, and a few bands of fine-grained graywacke. The nearest known igneous rocks are the green-

stones north of Gladhaugh Creek, nearly one-half mile away. All these rocks are of Orca age. The strike of the sedimentary beds at the mine is northwesterly; the dip is about 80° NE. The rocks were much crushed and sheared by faulting and shearing movements previous to the formation of the ore body. The strike and dip of the faults are approximately parallel to those of the bedding. A large fault, which strikes about S. 60° E. and dips 55° NE., has been found below the ore body on the 400 and 500 foot levels. The plane of this fault crosses the plane of the ore body between the 500 and 600 foot levels and is found again on the 600-foot level. The upper levels of the mine were not extended westward far enough to intersect this fault. Considerable movement has also taken place along the belt inclosing the Ellamar ore body, subsequent to the formation of the ore body, but apparently has resulted in only slight displacements.

The ore deposit.—The ore deposit is a large lenticular mass of sulphides. The major horizontal axis strikes about N. 35° W. The ore lens dips 80° NE. and pitches steeply toward the southeast. The strike and dip of the ore body appear to be the same as those of the bedding of the country rock. The maximum horizontal dimensions of the ore body are on the 200-foot level, where the major axis of the elliptical cross section is about 240 feet and the minor axis about 90 feet in length. The more highly mineralized portion of the outcrop of the ore body measured 80 by 130 feet and is now inclosed by the cofferdam. Less mineralized portions extend outside of the cofferdam along the strike of the ore body. The ore lens is reported to have pinched out between the 500 and 600 foot levels.

The ore body consists of two distinct parts—(1) a large lens of solid pyrite, forming the hanging wall for (2) smaller, closely packed parallel lenses consisting largely of other sulphides. These two parts are separated from each other by a thin but continuous band of black slate, which averages about 2 feet in thickness. Development work has not completely outlined the hanging-wall pyrite lens. It outcrops on the surface and is known to extend at least to the 300-foot level, where the horizontal dimensions of the lens are 160 by 20 feet. Its maximum thickness of 35 feet is on the 100-foot level. Its greatest stope length appears to be about 250 feet.

The distribution of the sulphides—chalcopyrite, pyrrhotite, sphalerite, and pyrite—within the second part of the ore body is irregular, and considerable country rock is included in the ore. This portion of the ore body contained the rich chalcopyrite shoot from which most of the copper ore mined in the past has come. In that portion of this second part of the ore body southeast of the copper shoot there is a gradual but marked increase in the amount of sphalerite present in the ore, a decrease in the copper content, and an increase in the gold and silver to such an extent that this portion of the ore body is

referred to as a gold ore shoot. Most of the ore mined in 1912 came from this shoot.

The ore.—The metallic minerals in the ore include chalcopyrite, pyrrhotite, pyrite, and sphalerite. Small amounts of galena are probably also present, as lead has been found in some of the assays. Chalcopyrite is the only copper-bearing mineral in the ore. A close association of sphalerite and gold is shown in the gold ore shoot, specimens of solid fine-grained sphalerite from which have assayed $22, $45, and $90 gold to the ton. The rich copper ore and the hanging-wall pyrite have a very low gold content.

The gangue minerals of the ore body include the country rock, quartz, brownish-black calcite, and white calcite. The black calcite is usually marked by fine striations, which are not seen on the later white calcite.

The order of deposition of the metallic minerals, as determined under a metallographic microscope, is (1) pyrite, (2) pyrrhotite, chalcopyrite, and sphalerite, all three contemporaneous and all later than the pyrite. The sulphides are later than the silicate minerals of the gangue. The black calcite is apparently contemporaneous with the pyrite and earlier than the white calcite and the other sulphides.

Ore genesis.—The Ellamar ore body is the only one of its kind within the Ellamar district. It has apparently resulted from the sulphide impregnation and replacement of shattered sedimentary strata by mineral-bearing solutions which probably obtained access to these beds along a faulted zone and deposited their sulphide content, impregnating and metasomatically replacing portions of the strata. The pyrite was deposited first with the black calcite, which may represent recrystallized limy portions of the original sediments. The pyrite and black calcite were then shattered. Further replacement took place by mineralizing solutions of slightly different character from those depositing the pyrite. Chalcopyrite, pyrrhotite, and sphalerite were deposited, partly at the expense of the pyrite. White calcite carrying these later sulphides recemented the fractures in the strained black calcite. The hanging-wall pyrite lens maintained its individuality, being but little affected by these later changes in the mineralizing process.

THREE MAN MINING CO.'S MINE.

Location of property.—The Three Man Mining Co. has a number of claims, locally known as the Dickey claims, about the head of Landlocked Bay. Most of the development work has been on the north side of the bay, and according to Mr. Dickey all the present productive workings are on the Keystone claim.

History and development.—The Keystone claim was staked about 1903. The only development on the property at that time was an

open cut close to the edge of the bay. After finding prospects there work was started on what is now tunnel No. 1 and ore was found within a few feet of the surface. A shipment of 12½ tons of ore, assaying a little over 12 per cent copper, from this tunnel was made in the fall of 1904. The developments in July, 1905, consisted of two 50-foot tunnels with some short drifts, one 20-foot tunnel, and a few open cuts. Forty-five tons of ore, assaying a little less than 13 per cent copper, are reported to have been shipped in 1906. Considerable development work was done in the following years, and a few irregular shipments of ore were made. In 1912 the mine became a regular producer. The present workings comprise 2,000 feet of adits and drifts on five levels, at elevations of 282, 235, 168, 122, and 57 feet. Considerable stoping has been done in a large sulphide ore body opened on levels 3, 4, and 5, and most of the ore shipped in 1912 came from this lens. A little development work was also in progress on the second and fifth levels.

Equipment and ore treatment.—No hoisting machinery has been necessary in the underground workings on account of the development of the property by adit tunnels. Hand drilling only is used in the exploration and exploitation of the ore bodies. There are several buildings on the property, including the manager's house, miners' eating and sleeping quarters, ore bunkers, and ore-sorting shed. A long wharf was completed in 1911. A short aerial tram extends from the mouth of No. 3 adit to the ore bunkers. The average number of men employed in 1912 was 25. Two 8-hour shifts were worked. Four of the men were employed in hand sorting the ore. The ore after sorting is stored in the bunkers until shipped to the Tacoma smelter.

The ore deposit.—The country rocks of the ore bodies are the greenstones, graywackes, and slates of the Orca group. The geology is complex on account of the extensive faulting. The trace of the Landlock overthrust fault crosses the head of Landlocked Bay just east of the present workings, and the rocks west of the fault plane and consequently below it have been intensely shattered, sheared, and faulted. A few of the shear zones are of considerable extent; many are short and narrow. Their strikes vary considerably, but most of them lie within the west-northwest system of fissuring. The dips are steep, 45° to 90°, and are principally to the north.

Much of the sheared material is mineralized. The ore bodies of workable size and shipping grade, however, are lenticular masses of nearly solid sulphides within the larger shear zones. Recent underground work has been confined to the exploitation of two ore bodies found in two of the larger shear zones. The two upper tunnels, Nos. 1 and 2, have exposed an ore body in the more northerly zone, and tunnels Nos. 3, 4, and 5 cut one in the southerly zone.

These two shear zones are but 20 feet apart on the level of tunnel No. 2. The northern zone strikes N. 60° W. and dips 35° N.; the southern zone strikes N. 75° W. and dips 65° N. The northern shear zone is thought to have been cut in 1912 in tunnel No. 5, 60 feet north of the other zone.

The dimensions of these ore bodies are not fully known. The width of the northern shear zone is 18 feet at the level of tunnel No. 1. The thickness of the ore body ranges from 1 to 6 feet of solid sulphides. The stope length has not been determined, and but 50 feet of the pitch length, that portion between the first and second levels, is known. The continuation of this ore shoot is thought to have been found in the end of tunnel No. 2, 140 feet northwest of the present stopes. Stoping has been confined on this shoot between the second and first levels, and only a small amount of ore has been removed.

The ore body in the southern of these two shear zones ranges from 2 to 9½ feet thick and has been cut on the second, third, fourth, and fifth levels. The present stopes would indicate a maximum stope length of about 80 feet. The pitch of the ore body is eastward at an angle slightly greater than the slope of the hill. On the fifth level at an elevation of 57 feet the ore body is 140 feet from the surface; on the third level only 20 feet; and above the third level erosion has removed a portion of the eastern edge of the ore body, which extends still farther up the slope. Considerable stoping has been done on this ore body between the fifth level and the surface cropping, and an outdoor stope has been started on the second level. A considerable portion of these ore bodies is solid sulphide ore.

The ores are partly replacements by sulphide minerals of the crushed material of the shear zones and partly the cementation of small fractures in the shattered rocks by solid sulphides. The sulphides present in the ore are chalcopyrite, pyrrhotite, sphalerite, and pyrite. A soft pale brass-yellow metallic mineral occurs intergrown with the chalcopyrite. This mineral has not been determined. It appears to be a new species, apparently a copper-iron sulphide with a low copper content. Specks of native copper are found in the weathered surface croppings of the lodes. The gangue minerals are quartz, calcite, and the sheared and altered country rocks.

LANDLOCK BAY COPPER MINING CO.

Location of property.—The property of the Landlock Bay Copper Mining Co. is situated on the south side of Landlocked Bay, on a narrow greenstone ridge projecting northwestward into the bay about one-half mile southwest of the Three Man mine. The property includes several claims, but the development work has been confined

to three of the claims. The present workings are on the northeast side of the ridge on the Moonshine claim.

History and development.—The discovery of copper ore on this property was made in 1898. The present owners took hold of the property in 1903, and the Landlock Bay Copper Mining Co. was incorporated in 1906. All of the underground development work has been done since 1903, and the present mine workings are reported to have been driven since the incorporation of the company. The present mine workings comprise about 500 feet of drifts, a 25-foot winze, and three short raises. There are three other tunnels on the property that total a little over 400 feet in length.

Equipment and ore treatment.—The mine has been developed by an adit tunnel 80 feet above sea level and by sinking and raising on the ore bodies from the tunnel level. No hoisting machinery is needed and only hand drilling is used in obtaining the ore. In October, 1912, four men were employed in mining and one in hand sorting the ore. Ore bunkers of a capacity of 800 tons have been built near the mine mouth. The living quarters are on level ground close to shore on the southwest side of the ridge. Seven men were employed on the property in 1912.

The ore deposit now being developed lies in a shear zone in a greenstone and black slate country rock. A crosscut tunnel was started 80 feet above sea level. The lead was cut 180 feet from the mouth of the tunnel, and 260 feet of drift has been driven along the shear zone, the strike of which changes from N. 76° W. in the western drift to north-south at the southeastern end of the present workings. The dip flattens from 65° N. to 30° E. along the drift. The width ranges from 4 to 15 feet. Two ore shoots have been found, each of which has a stope length of 25 to 30 feet and a thickness ranging from 1 to 7 feet. A 20-foot raise has been driven on one shoot and a 25-foot winze sunk on the other. The pitch lengths of these shoots have not been determined. Ore from the winze is said to average at least 7½ per cent copper. Another 20-foot raise was driven in the shear 25 feet west of the winze on 10 to 12 inches of ore which is said to assay 4 per cent.

A copper-bearing shear zone on the south side of the ridge, 300 feet above sea level, strikes S. 60° E. and dips 67° N. Its width ranges from 2 to 5 feet. The outcrop is traceable for some distance east and west of a shaft which has been sunk on the shear zone. The country rock is greenstone and hard blocky slates. The ore is bunchy. A crosscut tunnel has been started northward to intersect this lead. Other undeveloped mineralized shear zones are reported on the property.

The ores are chiefly replacements by sulphide minerals of the crushed material of the shear zones. To a much less extent the sul-

phides fill small fractures in shattered black slate. The sulphides include chalcopyrite, pyrrhotite, sphalerite, and a few specks of an undetermined sulphide resembling the sulphide found at the Three Man mine. The gangue includes quartz, calcite, slate, and greenstone. Much of the calcite has a fine white sugary appearance.

GALENA BAY MINING CO.

The prospects of the Galena Bay Mining Co. are situated on the north slope of Copper Mountain near the head of a southerly tributary of Millard Creek and are about 3 miles from the head of Galena Bay.

The principal underground development is a long tunnel 916 feet above sea level driven S. 54° E. to intersect a large shear zone which outcrops on the eastern side of the valley. In 1905 the tunnel was being driven by the Prince William Sound Mining Co. and had a length of more than 300 feet. The property was later taken over by the Galena Bay Mining Co. In August, 1908, the tunnel had reached a length of over 1,500 feet. In 1909 this tunnel was extended to 1,800 feet and some diamond drilling was done from the end of the tunnel. Further drilling was done on the Sunnyside claim on the west side of the valley. The tunnel has since been extended, according to reports, to a length of 2,200 feet. Several other shorter tunnels have been driven on the various claims. Only assessment work was done in 1912.

Considerable money has been expended in the development of this property. Several buildings have been erected at the head of Galena Bay and at the mine, a road built between the bay and the mine, and a telephone system installed connecting the mine, power house, and buildings at the bay. A dam erected on Millard Creek about a mile from Galena Bay gives a 52-foot head of water. The current generated at the power plant installed here was used to operate an air compressor at the mine tunnel and to light the entire camp. Material for an aerial tramway from the mine to tidewater was on the ground in 1908, but the tram has not yet been erected.

The principal ore bodies upon which development work has been done are the Vesuvius, Copper Crown, and Sunnyside claims. The country rock is predominantly greenstone, with some graywacke and slate. The greenstones are ellipsoidal in places.

The 2,200-foot crosscut tunnel was started north of and beneath the shear zone on the Vesuvius claim, which it was intended to intersect and which outcrops on the east side of the valley. The tunnel was started on a small iron-stained shear zone carrying a few small stringers of chalcopyrite, pyrrhotite, pyrite, and quartz. Seventeen hundred feet from the mouth the tunnel forks. The right branch was driven forward until a wet strip (possibly the Vesuvius shear zone)

was reached. The left branch was swung a little to the north and was then continued for 500 feet. At the end it separates into three branches, each about 50 feet in length. The main shear zone was not recognized in the tunnel.

On the surface the Vesuvius shear zone passes between the mouth of the crosscut tunnel and the steep rock bluff a short distance to the south. To the west it heads for the low saddle on the Sunnyside claim. To the east it extends up the steep east wall of the valley toward the Landlock overthrust fault. At an elevation of 1,060 feet a 15-foot adit tunnel has been driven on a poorly developed shear zone which strikes N. 75° W., dips 60° N., and contains a few lenses of chalcopyrite, pyrrhotite, quartz, and calcite, 4 to 5 feet in length and up to 14 inches in width. At 1,180 feet a 20-foot tunnel has a long, narrow epidote-bearing quartz vein in the face but contains no ore. At 1,400 feet a 15-foot adit tunnel is driven on the Vesuvius shear zone and the ore which has thus far been found on this claim is said to have been found in this tunnel and above it. The shear zone is about 20 feet wide, strikes N. 50° W., and dips steeply to the south. Some ore is found in this tunnel but no solid masses of sulphides. At an elevation of 1,450 feet the shear zone splits. The south fork strikes N. 30° W. and dips vertically. The north fork strikes N. 50° W. and dips 70° S. The shear zone has a width of 12 feet at 1,500 feet elevation and is heavily iron-stained. Quartz, calcite, pyrrhotite, and chalcopyrite occur in narrow irregular stringers in the sheared and shattered greenstones and slates. The principal sulphide is pyrrhotite.

The lead on the Copper Crown claim is located at an elevation of 2,250 feet on the east wall of the cirque at the head of the valley. Where best developed 4 feet of solid sulphide ore is contained in a shear zone striking N. 75° E. and dipping 80° S. The country rock is massive unsheared greenstone. The width of the shear zone ranges from 3 inches to over 4 feet. The mineral content also varies and in places there are only a few narrow stringers of sulphides. The shear zone is traceable to the northeast about 250 feet and then appears to pinch out. In this portion the lead changes to a fairly well defined quartz vein carrying small amounts of sulphides. The quartz is frozen to the walls. An open cut has also been made on the shear zone 200 feet southwest of the 4-foot sulphide open cut referred to above. Here the lead strikes N. 65° W. and dips 75° N. The width ranges from 2 to 5 feet and some good ore is exposed. The walls are sheared ellipsoidal greenstone. Average assays of 12 per cent copper are reported on ore from this shear zone, but so far the only development work done has consisted of a few open cuts.

The Sunnyside claim is located on the ridge west of the cabins. The country rock is principally greenstone, much shattered, cemented by a fine network of quartz veinlets, and extensively mineralized. There are numerous small shear zones with different strikes, the majority of which, however, lie within the east-west system of fissuring. No large continuous shear zones have been found. The distribution of the mineralization is irregular and bunchy. A 28-foot tunnel has been driven at an elevation of 1,550 feet on a shear zone that strikes S. 70° E. The ore is principally pyrrhotite with small amounts of chalcopyrite in the sheared and shattered greenstones. The upper and longer tunnel, which has about 400 feet of drifts and two winzes, one of which is 60 feet deep, is at an elevation of 1,700 feet. Two ore bodies, containing ore said to average as high as 12 to 14 per cent copper, were struck in this tunnel. The larger ore body is said to have measured approximately 75 by 20 by 12 feet.

Other short tunnels have been driven on small and not very extensive shear zones carrying a few small bunches and stringers of ore. A shallow shaft on the crest of the ridge, which is sunk on a 5-foot shear zone that strikes N. 10° W. and dips 85° E., contains a 20-foot lens, 8 inches wide in places, of solid sulphides.

The ores, with the exception of a portion of the Copper Crown lead, are believed to be partly replacements of the sheared and shattered greenstones and partly the filling of tiny fractures in the shattered rocks by solid sulphides. The sulphide minerals comprise chalcopyrite, pyrrhotite, pyrite, and sphalerite. The gangue minerals are quartz, calcite, and the sheared and altered country rock. A portion of the Copper Crown lead is plainly the filling of an open fissure by a siliceous sulphide-bearing solution. The sulphides deposited in this portion of the lead are the same as those in the replaced portions.

FIELDER & HEMPLE PROSPECT.

The Fielder & Hemple prospect is situated at the northeast corner of Boulder Bay, a short distance northeast of the property of the Reynolds Alaska Development Co. The lower and longer tunnel is at an elevation of 350 feet above sea level.

The development work consists of two tunnels and some surface stripping. The lower tunnel, which has 260 feet of drifts and a 25-foot raise, was driven to intersect a shear zone which outcrops about 100 feet above the tunnel mouth. The upper tunnel, 20 feet long, at an elevation approximating 450 feet above sea level, is driven along the shear zone.

The country rock at the lower tunnel is greenstone with some hard black slate, fractures in which are filled with quartz. No well-

defined shear zone or ore body was seen in this tunnel. At the adit tunnel the country rock is all greenstone. The ore deposit consists of a poorly mineralized shear zone in greenstone lying at the foot of an overhanging ellipsoidal greenstone bluff. This shear zone strikes N. 45° E., dips 65° N., and is from 25 to 30 feet wide. The shearing is poorly developed. The ore occurs in small bunches up to 10 inches thick and consists of much fine-grained pyrite with only a little chalcopyrite, pyrrhotite, and quartz.

PROSPECTS OF REYNOLDS ALASKA DEVELOPMENT CO.

The Landlocked Bay property of the Reynolds Alaska Development Co. is situated near the head of a small northerly tributary to Landlocked Bay and is about a mile from the head of the bay.

The first discovery on the property is reported to have been made by Joseph Putz and Peter Steinmetz about 1899. Other claims were located later. The Reynolds Alaska Development Co. was formed in 1903 and is reported to have obtained control of the Landlocked Bay claims in 1904 or 1905. There is about 900 feet of underground development work on the property at the present time, including two long tunnels, which have 600 and 220 feet of workings, respectively, several short tunnels, open cuts, and a shallow shaft. Surface improvements include a trail from tidewater to the mines, a small warehouse at the bay shore, and a few buildings near the upper workings. No development work has been done on the Boulder Bay property since Grant's visit.[1]

The ore bodies comprise several small shear zones lying close to but a little to the west of the Landlock overthrust fault. The country rock is interbedded greenstone, graywacke, and blue-black slate. At the lower tunnel, 600 feet above sea level, a shear zone 5 feet in width was cut 60 feet from the tunnel mouth and a drift was carried 110 feet N. 35° W. along the shear, which dips 55° N. This shear zone is reported to average 5 per cent copper, though some higher-grade ore is said to have been obtained in a 6-foot winze sunk on the lead where the shear zone was first struck in the tunnel. This shear is reported to be traceable on the surface for a considerable distance. A shaft 16 feet deep was sunk near the upper cabins in an iron-stained outcrop of much-jointed greenstone showing small patches of chalcopyrite-pyrrhotite ore, which have a maximum thickness of 2 inches, and considerable disseminated sulphides in the more highly shattered portions. A sample taken across 20 feet of this outcrop is said to have averaged 1 per cent copper.

At an elevation of 845 feet a 600-foot tunnel has been driven toward Copper Mountain on an iron-stained shear zone, 3 to 4 feet

[1] Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: U. S. Geol. Survey Bull. 443, p. 61, 1910.

wide, which has been traced up the slope by open cuts for a short distance. Sixty feet above the tunnel mouth the shear zone contains 4 feet of solid sulphide ore. No well-defined continuous lead or zone was observed in the tunnel, although numerous well-defined joints exist. Very little ore was seen. Sulphide stringers, having a maximum thickness of 3 inches and showing more pyrrhotite than chalcopyrite, are found in places, and the sulphides also occur disseminated in the greenstone.

At an elevation of approximately 1,000 feet two short adit tunnels, 30 and 35 feet in length, have been driven on parallel leads in greenstone 100 feet apart that strike N. 60° E. and dip 60° N. Considerable ore, some of which is reported to average 8 per cent copper, is exposed in the workings. Some of the sulphide lenses are 8 to 10 inches wide.

The ores are believed to be replacements and impregnations of sheared greenstones by the sulphides, chalcopyrite and pyrrhotite. Pyrrhotite is the more abundant. The percentage of chalcopyrite present is indicated by the fact that the best assay reported, on picked specimens, showed between 9 and 10 per cent copper. The average copper content of the ore is much less. The gangue material comprises quartz, calcite, and sheared greenstone. Unreplaced fragments of the dark sheared greenstone are scattered through the masses of solid sulphides.

STANDARD COPPER MINES CO.

The underground workings of the Standard Copper Mines Co. are on the steep south face of Copper Mountain between 1,400 and 2,100 feet above Landlocked Bay. The present company was organized in 1906 and most of the development work on the property has been done since that date. The tunnels are connected by an aerial tram, with 500-ton ore bunkers on a wharf on Landlocked Bay. Other surface improvements include the manager's house, office, and a large bunk house, all in good condition, on the shore of Landlocked Bay, and camp buildings near the upper end of the tram line. A few tons of ore are reported to have been shipped between 1906 and 1911. The property was idle in 1912.

The underground workings total about 1,300 feet in length and consist of five tunnels, in which the lengths of the workings are about 660, 290, 175, 85, and 28 feet, respectively. A 50-foot winze has been sunk in the longest tunnel at a distance of 54 feet from the mouth.

The ore bodies consist of lenticular masses of sulphides, of variable length and width, and of bunches of sulphides at the intersection of shear zones. The country rock of the shear zones is principally greenstone but includes some graywacke and black slate. The geol-

ogy is complex, on account of much shearing and faulting. The ore bodies, however, all lie within the greenstone division of the Orca group.

Tunnel No. 1, driven at an elevation of 1,820 feet, is 175 feet long and is situated at the head of the short branch of the aerial tram. Several lines of shearing intersect in the vicinity of this tunnel, and the following bearings have been recorded on these shear zones: Strike N. 90° E., dip 60° N.; strike north-south, dip 60° W.; strike N. 45° W., dip 65° NE.; strike N. 70° E., dip 60° N.; strike N. 75° E., dip 35° N.; strike N. 55° E., dip 50° N. Their width ranges from 1 to 20 feet. The linear extent of most of the shear zones is not known. The zone which crosses this tunnel 30 feet from the mouth and strikes N. 75° E., with a 35° dip to the north, is traceable on the surface for over 100 feet. A 10-foot raise on this shear zone shows considerable chalcopyrite in the face. In a gulch a short distance east of this tunnel about 1½ feet of solid sulphide ore is reported in a 5-foot shear zone which strikes N. 55° E. and dips 50° N. Stringers of mixed chalcopyrite and pyrrhotite having a maximum thickness of 1 inch fill cracks in the overlying ellipsoidal greenstone. Thirty feet farther east this shear zone is much less mineralized.

A short tunnel, driven at an elevation of 1,800 feet just west of the long branch of the aerial tram, crosscuts a shear zone about 20 feet wide, possibly the same as the one mentioned above, and is then driven 8 feet along the shearing. This shear zone strikes approximately N. 60° E. and dips 60° N. A little good ore is piled in front of this tunnel.

Tunnel No. 2, at an elevation of 2,070 feet, has 660 feet of underground development work. This tunnel was driven to intersect three ore-bearing zones outcropping on the mountain above. The lowest zone, encountered 45 feet from the mouth of the tunnel, strikes N. 55° E. and dips 45° N. A winze 50 feet deep has been sunk on this lead. Tunnel No. 4, driven along this same shear zone, crosses tunnel No. 2 at this point. Several hundred tons of ore, most of which has been shipped, are reported to have been mined from this zone. Two hundred and thirty feet from the tunnel mouth a 33-foot drift has been driven on a narrow 1½-foot mineralized shear zone. Three hundred and fifty feet in a drift has been driven 260 feet S. 60° W. along a narrow mineralized shear zone, 3 to 6 feet wide, which dips 40° N. Numerous small quartz-calcite stringers are inclosed in the shear. The ore is reported to assay 4 to 5 per cent copper.

Tunnel No. 3, at an elevation of 1,450 feet on the short branch of the aerial tram, is 290 feet long. The greenstone at this tunnel as a whole is massive and not badly sheared. The face is in blocky black limy slate. A short distance inside of the tunnel a wide shear

zone, which strikes N. 40° W. and dips 60° N., is crossed. The sheared portions are 2 inches to 2 feet thick and are separated by several feet of solid greenstone. Joints at the mouth of the tunnel strike N. 15° W. and dip 55° W. A shear zone 50 feet west of the tunnel strikes N. 10° W. and dips 80° W. Malachite staining is abundant at the mouth of the tunnel.

Forty-five feet from its mouth tunnel No. 2 is crossed by tunnel No. 4, which is driven on a shear zone, 3 to 15 feet in width, that strikes N. 55°–80° W. and dips 60° N. Tunnel No. 4 was started in a gully 30 feet east of tunnel No. 2, which it crosses, and extends about 50 feet beyond to the west. The shear zone is stoped to the surface, except for the last 25 feet. Lenses of sulphides and sheared greenstones lay within the shear zone. The average sulphide content of the entire zone is estimated to be equivalent to a band of solid ore 20 inches thick. The relative proportions of the sulphides vary. The copper content of this ore is not known.

The ores are probably replacements of the crushed filling of the shear zones combined with the cementation of numerous small fractures in the shattered rocks by sulphide minerals. These comprise chalcopyrite, pyrrhotite, and sphalerite. The gangue includes calcite, quartz, and the sheared and altered country rock.

PROPERTY OF HEMPLE COPPER MINING CO.

The property of the Hemple Copper Mining Co. lies just north of the Three Man Mining Co.'s ground near the head of Landlocked Bay. The company was organized in March, 1910, and its holdings are reported to consist of six claims, all patented, and a 2-acre mill site. The claims are timbered. Surface improvements include camp buildings near the lower tunnels and a good trail to the property from Landlock. There is about 1,350 feet of underground development work, comprising four tunnels, whose workings are 800, 450, 65, and 18 feet in length, respectively; two shallow shafts, 10 to 15 feet deep; and numerous open cuts. At the lower tunnel, 450 feet above sea level, a Fairbanks-Morse gasoline engine, belt-connected to a small fan, is used to ventilate the workings. The property was idle when visited in 1912.

The country rock consists of greenstone, black blocky slate, and graywacke. Only one copper lead is reported on the property, a shear zone that is of variable width but is said to average 24 feet. Measurements of 5, 9, 10, 15, and 35 feet were made during the present investigation at different points across the sheared zone, which has been traced, by stripping, open cuts, shallow shafts, and tunnels, for over 1,500 feet. The strike of the shear zone changes gradually from N. 55° W. near its eastern end to east-west at its western end. The dip remains constant at about 60° N.

The distribution of the metal content of the shear zone as a whole is decidedly irregular. Within the more highly mineralized portions the metallic ore minerals are irregularly distributed as stringers, lenses, and bunches of solid sulphides or occur disseminated through the crushed material. Some of the calcite stringers and bunches in the sheared greenstone also carry small amounts of sulphides. Stringers and lenses of pyrrhotite and chalcopyrite 2 to 18 inches thick lie parallel with the shearing, and a few large irregular masses of solid sulphides are occasionally found. The entire width of the shear zone may be mineralized in some places, whereas in others but little evidence of metallization is visible—for instance, at the west end of the lead, where above the 65-foot crosscut tunnel the iron-stained outcrop of the shear zone has been exposed for over 100 feet. At this locality the ore body shows a maximum width of 10 feet at the center, narrowing at both ends, beyond which but little metallization is evident. The mineralized mass shows a lenticular cross section and contains long, narrow lenses and stringers of solid sulphides up to 1 foot thick, irregularly distributed throughout the ore body, as well as considerable quantities of disseminated sulphides.

The ores are probably chiefly replacements by sulphide minerals of the crushed and altered material of the shear zone and fillings of numerous small fractures in the shattered rock by solid sulphides. The sulphide minerals include pyrrhotite, chalcopyrite, and sphalerite. Pyrrhotite is much more abundant than the other sulphides. The gangue minerals are calcite, quartz, and the sheared and altered country rock. Average assays of the mineralized portions of the shear zone are reported to show from 3 to 6 per cent copper. One assay of a sample taken previous to 1905 across a former face of the lower tunnel showed 6 per cent copper, $1.20 in gold, and $1.50 in silver. The copper content of the solid sulphide lenses is reported to be about 6 per cent.

PROSPECTS OF THE THREE MAN MINING CO.

Besides the producing mine at the head of Landlocked Bay the Three Man Mining Co. has several prospects at which considerable work has been done. These include the ground formerly owned by the Alaska Commercial Co. on Landlocked Bay, the Montezuma claim on Copper Mountain, some claims on the south side of Landlocked Bay, and others near the summit on the Fish Bay side of the divide between Landlocked Bay and Fish Bay. These will be described briefly.

WORKINGS OF ALASKA COMMERCIAL CO.

The workings of the Alaska Commercial Co. are on the north side of Landlocked Bay near its head and only a short distance west of the Three Man mine. This prospect was located in 1897 by Louis Jacob-

son and is reported to have been the first discovery of copper ore by white men in this district. Undergro ınd development work includes a 412-foot crosscut tunnel driven in 1898–99 at an elevation of 200 feet above sea level and two shorter adit tunnels driven at a later date, having a reported length of 100 and 20 feet, respectively, 250 feet above the lower tunnel. Several tons of high-grade ore are said to have been shipped from the upper tunnels. Since the Three Man Mining Co. has obtained control of the property a drift has been started in the crosscut tunnel about 210 feet from the mouth of the tunnel. In 1912 two men were employed extending this drift eastward.

The country rock of the ore deposit is chiefly greenstone, more or less ellipsoidal, with some interbedded black and gray slates and light-colored fine-grained graywackes. The strikes and dips of the sedimentary beds vary. In the lower crosscut tunnel a strike of N. 30° W. and a dip of 50° E. was observed. Near the upper tunnels the strike is N. 20° W. and the dip 70°–80° E. In a gulch east of the upper tunnels and at an elevation of 400 feet a graywacke and black slate band 40 feet or more in thickness strikes N. 5° E. and dips 70° E.

The ore occurs in a shear zone about 30 feet wide, which carries large lenses of massive unsheared greenstone around which the sheared strips bend. The ore lies in the narrower and more sheared portions and in joint cracks in the massive lenses and the country rock. Some of the smaller sheared strips, 2 to 6 inches wide, are slightly mineralized. The adit tunnels are driven in the more highly mineralized part of the shear zone, a narrow greenstone band ranging from 2 to 10 feet in width but probably averaging only about 4 feet. This band strikes S. 85° E., dips 60° N., and is traceable about 250 feet along the strike. It extends about 75 feet west of the present tunnels but is not well developed. In a gulch at the east end of the known outcrop 2 feet of solid pyrrhotite has been found. In the adit tunnels a few lenses and streaks of chalcopyrite and pyrrhotite, with a thickness of 2 to 8 inches, are present. The largest lens is said to have shown a thickness of 18 inches of solid chalcopyrite and pyrrhotite.

The long crosscut tunnel was driven to intersect the large shear zone outcropping above, but no ore was found in the main tunnel. Development work in the winter of 1912–13 in the east drift in this tunnel exposed a foot of solid pyrrhotite but no chalcopyrite.

The ore is probably chiefly a replacement of the sheared greenstone, with some cementation of small fractures by solid sulphides. The sulphide minerals present are chalcopyrite, pyrrhotite, sphalerite, galena, arsenopyrite, and the unknown sulphide also found at the Three Man Mine. Gold and silver are reported in assays of the copper ore. The presence of galena and arsenopyrite in this ore is noteworthy.

With the exception of pyrite, which was not observed in the specimens examined, the association of metallic minerals is the same as that in the gold-quartz veins of the Prince William Sound region. The gangue minerals include quartz, epidote, and the products formed by the shearing and hydrothermal alteration of the greenstone.

MONTEZUMA CLAIM.

The Montezuma claim is situated on the steep south slope of Copper Mountain, a little lower and a little to the east of the workings of the Standard Copper Mines Co. The developments comprise a straight crosscut tunnel 350 feet long at an elevation of 1,300 feet above sea level, one short crosscut tunnel about 10 feet long, an adit tunnel of similar length, and considerable stripping, reported to be about 900 feet in length, along the lead which outcrops at about 1,400 feet elevation.

The country rock of the lead is principally greenstone with a few beds of interlayered black slate which, where seen, have a maximum thickness of 15 feet. The ore occurs in a mineralized shear zone 20 feet in width which strikes due east and dips 65° N. Erosion of the outcrop of this shear zone has resulted in a well-defined shallow trough, which is traceable for a considerable distance eastward toward the head of Landlocked Bay. The mineralization of the shear zone is irregular. Copper ore is reported to have been found in all the pits along the 900 feet for which the lode has been traced by the owners. The ore was formed by impregnation and replacement of the sheared material by chalcopyrite and pyrrhotite. Some quartz accompanies the sulphides. Lenses of solid chalcopyrite and pyrrhotite 1 to 4 inches thick have been found in some of the open cuts. These sulphides also occur disseminated in the sheared material.

Actual development work on the ore body has thus far been confined to surface strippings and the two short tunnels. The 350-foot tunnel was driven to crosscut this lode but has not yet reached the main shear zone. A small copper lead, however, is reported to have been crossed in this tunnel. The main shear zone, which is well defined and of considerable length, is mineralized, and later development may disclose bodies of profitable ore within it.

CLAIMS ON SOUTH SIDE OF LANDLOCKED BAY.

Four tunnels, 115, 65, 35, and 5 feet in length, have been driven on claims belonging to the Three Man Mining Co. on the south side of Landlocked Bay. These workings are located S. 45° E. of Copper Mountain and between elevations of 450 and 650 feet above sea level. A trail leads from Landlocked Bay to the tunnels, which have been driven at different elevations in slightly mineralized shear

zones in interbedded black slates, graywackes, and greenstones. The recorded strikes and dips of the various shear zones examined are (1) strike S. 75° E., dip 40°–50° N.; (2) strike N. 65° E., dip vertical; (3) strike N. 35° W., dip 35° N.; (4) strike S. 85° E., dip 52° N. The stripped outcrops of the shear zones are iron stained in places, with exceptionally a little copper staining. Small lenses of quartz carrying chalcopyrite and pyrrhotite are visible in the lowermost open cut. Very little ore was found in any of the workings. Both greenstones and slates were slightly mineralized, chalcopyrite and pyrrhotite being the sulphide ore minerals.

WORKINGS ON THE FISH BAY SIDE OF BILLY GOAT MOUNTAIN.

The workings on the Fish Bay side of Billy Goat Mountain consist of short tunnels at elevations of approximately 1,150 and 1,750 feet above sea level. The country rock of the ore bodies is massive greenstone. The lower tunnel is driven 30 feet northeastward on a slightly sheared zone along a master joint which strikes N. 45° E. and dips 45° E., at the base of a 50-foot bluff of massive greenstone. The thickness of the sheared zone ranges from a fraction of an inch up to 6 inches. Slight copper and iron staining appears along the shear zone, which carries a few stringers of chalcopyrite and pyrrhotite and a little quartz. The greenstone beneath the tunnel is much shattered and contains irregular, barren-looking quartz-calcite veins, short and lenticular, the largest ones being 3 feet in width and 10 to 12 feet in length.

The upper workings are in a vertical copper-stained bluff of greenstone. The tunnels are driven along small shear zones, which strike S. 70° E. and dip 30°–50° N. The largest body of ore is reported to have been not over 8 feet long, with a maximum width of 1 foot, and is said to have contained about 6 per cent copper. The sulphides of the ore are chalcopyrite and pyrrhotite. The ores are of the usual type—sulphide impregnations and replacements of the sheared greenstone.

HOODOO CLAIM.

The Hoodoo claim is situated on the south shore of Landlocked Bay, a short distance east of the ore bunkers of the Landlock Bay Copper Mining Co. This claim was located January 1, 1904. Thomas B. Grove and the Three Man Mining Co. have each a half interest in it. The workings include considerable surface stripping and three tunnels, 180, 60, and 15 feet long, of which 105 and 45 feet, respectively, of the two longer tunnels were driven in slide. The remainder of the tunnels is in solid rock. A 30-foot raise has been driven to the surface in the long tunnel. The 60-foot tunnel was driven in 1903. Two men were at work on the property in 1912.

The country rock of the ore bodies is greenstone. The last 75 feet of the long tunnel is driven S. 66° E. on a shear zone in the greenstone, which dips 60° N. The ore is said to have ranged from a thin film to 2 feet in thickness and to have averaged 4 to 5 per cent copper. A 30-foot raise was put in to the surface along the footwall of this lead where it was first struck in the tunnel in 1910. Surface stripping at an elevation of 230 feet above sea level has exposed for about 75 feet a 3-foot band of mineralized sheared greenstone, which strikes N. 45° W. and dips from 60° NE. to nearly vertical. A network of tiny quartz veinlets shows on the iron-stained outcrop of the lode. The 15-foot tunnel, 150 feet above the cabin, is driven S. 60° E. on a lead reported to show 3 feet of copper ore in the face of the tunnel. One hundred feet east of the long tunnel and at the same level stripping has exposed an 18-inch shear zone in greenstone. This lode strikes S. 30° E., dips 55° NE., and carries a little copper.

The sulphide minerals of the ore are chalcopyrite, pyrrhotite, and sphalerite. Native copper is found in the iron-stained surface that crops out above the 15-foot tunnel. The ore carries only a small amount of copper, but assays of $10 to $22 gold are reported. Quartz is an abundant gangue mineral.

GOLD QUARTZ LODES.

A few gold quartz claims have been located in different parts of the Ellamar district on stringers, lenses, and stockworks of gold-bearing quartz, but no prospects of economic importance have as yet been found. Several large low-grade quartz masses are reported on the seaward side of Bligh Island. Near the entrance to Cloudman Bay there is a stockwork of quartz veins in slate 20 to 30 feet wide, containing about equal quantities of quartz and slate. The strike is a little east of south and the dip 65° N. A 4-inch gouge seam forms the south wall and two small faults with gouge were seen at the left edge. Most of the cropping is below high tide, but the lode is stripped 40 feet back from the beach. The quartz is drusy. The sulphides include chalcopyrite, pyrite, and sphalerite. The ore is reported to average $2 to $4.80 on samples taken across the entire 30 feet.

Just back of this ledge is an old Alaska Commercial Co. prospect on a bunch of gold quartz on which assays as high as $2,500 are said to have been obtained. The bunch of ore is reported to have been blown out. The shaft is now caved in and there is nothing to be seen.

In a bay at the north side of Graveyard Point Mr. L. E. Banzer has put down a couple of shafts and done several hundred feet of stripping, all now fallen in and covered. The shafts are full of water. The slate and greenstone in this vicinity is much contorted and crumpled, but the general strike seems to be a little south of east with

a steep northeasterly dip. The slates have many stringers and bunches of quartz up to 6 inches thick. In the bottom of one of the shafts a lead 2 feet wide is reported. On the dump is a good deal of quartz carrying sulphides. Chalcopyrite, pyrrhotite, pyrite, sphalerite, and galena are found in the ore and a little calcite is included in the gangue. Assays as high as $50 in gold to the ton are reported on this ore, but it is not known that this was an average sample.

MINERAL DEPOSITS OF KODIAK AND THE NEIGHBORING ISLANDS.

By G. C. MARTIN.

GEOGRAPHY.

POSITION AND SHORE LINE.

Kodiak is one of a group of islands situated south of the entrance to Cook Inlet, Alaska, in latitude 56° 30′ to 59° N. and longitude 152° to 154° 45′ W. They are separated from the Alaska Peninsula by Shelikof Strait, which is about 30 miles in width. The group includes two large islands, Kodiak and Afognak, which are separated by narrow channels, and several smaller ones near by. The entire group lies southwest of Kenai Peninsula. It is in the trend of the Kenai Mountains and is probably part of their submerged extension. The Barren Islands, which lie in the mouth of Cook Inlet, midway between Afognak and Kenai Peninsula, form a link in this broken chain. The group has a seaward extension in the Trinity Islands and Chirikof Island, which lie, respectively, 10 and 80 miles southwest of Kodiak Island.

Kodiak Island is about 100 miles long from northeast to southwest and 60 miles wide from northwest to southeast. It is of roughly quadrangular outline (Pl. V) but is intricately indented by numerous long bays and is almost bisected by Uyak Bay. Afognak Island is about 40 miles long and 25 miles wide and is almost a miniature of Kodiak Island in outline and orientation.

TOPOGRAPHY.

The islands are mountainous throughout. On Kodiak Island the general altitude of the higher summits along the northeast and northwest coasts is from 2,500 to 3,000 feet. The highest mountains are probably near the center of the island, a peak near Uyak Bay (the highest known summit) having an altitude of 4,463 feet. The mountains near the south coast of the island are said to be high and rugged. On Afognak Island the general maximum altitudes are from 2,000 to

2,300 feet. No considerable areas of lowland occur on any of the islands.

The general drainage of both Kodiak and Afognak islands is northwest and southeast from divides lying near the center of each island and extending roughly parallel to its longest dimension. Each bay receives the drainage from its proportion of the area contiguous to it, there being no extensive river systems. The only large stream is Karluk River, and the only important lakes are Karluk Lake on Kodiak Island and Afognak Lake on Afognak Island, which are 13 and 6 miles long, respectively.

VEGETATION.

The low slopes of Afognak Island and of the northeastern part of Kodiak Island are covered with a light spruce forest. On Kodiak Island the limits of the spruce forest are at Uganik and Ugak bays, west of which there are no trees except cottonwood and birch. Timber line is low, there being practically no trees anywhere above an altitude of 1,000 feet. Large areas of grass are found among the woodlands on the gentler hill slopes and in the valleys. The customary growth of bushes and shrubs occurs among and above the forests.

CLIMATE.

The climate of the islands is mild and moist, showing the influence of the surrounding sea. The following tables give a summary of the meteorologic records:[1]

Monthly temperature (°F.) at Kodiak and Wood Island from January, 1899, to December, 1910.

	Maximum.	Minimum.	Mean.
January, 10 years	53	−8	28.92
February, 10 years	58	−3	33.17
March, 11 years	65	2	34.60
April, 10 years	61	5	36.24
May, 11 years	74	20	43.52
June, 11 years	82	30	51.11
July, 12 years	82	32	53.14
August, 10 years	85	31	55.22
September, 10 years	77	26	49.41
October, 10 years	67	16	41.15
November, 11 years	54	9	34.50
December, 9 years	61	−12	30.57
For term of record	85	−12	40.98

[1] Georgeson, C. C., Ann. Rept. Alaska Agricultural Exper. Sta., for 1902, pp. 302–303; 1903, p. 386; 1904, p. 358; 1905, p. 97; 1906, p. 71; 1907, p. 91; 1908, p. 76; 1909, p. 74; 1910, p. 77.

Monthly precipitation (inches) at Kodiak and Wood Island from January, 1899, to December, 1910.

	Maximum.	Minimum.	Mean.
January, 11 years	4.80	1.00	3.23
February, 11 years	8.60	.30	4.94
March, 10 years	7.46	.00	3.37
April, 10 years	7.40	2.60	4.42
May, 11 years	6.62	3.35	5.07
June, 11 years	7.80	1.55	3.86
July, 10 years	6.64	.82	3.75
August, 9 years	9.20	1.75	4.17
September, 10 years	10.00	.63	4.46
October, 10 years	8.95	1.86	6.32
November, 11 years	14.11	1.42	5.72
December, 10 years	11.10	1.88	5.87
Annual average			55.18

SETTLEMENTS, INDUSTRIES, AND TRANSPORTATION.

All the inhabitants of the islands live in small towns and villages situated on the shore. The most important town is Kodiak, or St. Paul, which is situated near the east end of Kodiak Island. Kodiak is the western terminus of a line of steamers from Seattle and is also a port of call for a steamer running monthly from Seward to Unalaska. The only industries of the town are salmon and halibut fisheries.

Other salmon canneries are situated at Larsens Bay, Uyak, Karluk, and Alitak. Russian and native settlements, which are not supported by any important industries, include the villages of Afognak, Uzinki, and Uganik. A salmon hatchery is situated at Litnik on Afognak Island. An agricultural experiment station was established several years ago at Kalsinski, a few miles south of Kodiak. The village of Wood Island, near Kodiak, contains the Kodiak Baptist orphanage.

Grazing and agriculture, which constitute the most important industries of Kodiak Island, next to the fisheries, received a serious but probably only temporary setback in the severe injury to vegetation caused by the eruption of Katmai Volcano in June, 1912. Other local industries are trapping and fox raising.

Mining has never attained the rank of an important industry on these islands, although moderate amounts of placer gold have been obtained from the beaches on the northwest and southwest coasts for many years. A small amount of gold has also been obtained from a lode mine on Uyak Bay. The average net effect of mining and prospecting on Kodiak Island thus far has probably been to impoverish rather than to enrich both the individuals who took part in it and the community as a whole.

All travel in these islands is by water. There are no roads and but few trails. There are no serious difficulties in the way of land transportation, but the water routes are so convenient that there is little need for roads or trails.

GEOLOGY.

GENERAL FEATURES.

The rocks of Kodiak and the neighboring islands consist chiefly of slate and graywacke, cut by numerous but for the most part small intrusive masses, partly granitic. They are probably underlain by metamorphosed schists and overlain by small areas of poorly consolidated Tertiary rocks and by a variety of unconsolidated Quaternary beds. (See Pl. V.) The general sequence is indicated below:

Quaternary:
- Alluvial and beach deposits.
- Glacial and terrace gravels.

Tertiary:
- Sandstones (?).
- Lignite-bearing beds (?).

Mesozoic (?):
- Granitic intrusive rocks.
- Graywacke and slate.

Paleozoic (?): Schist, greenstone, quartzite, and marble.

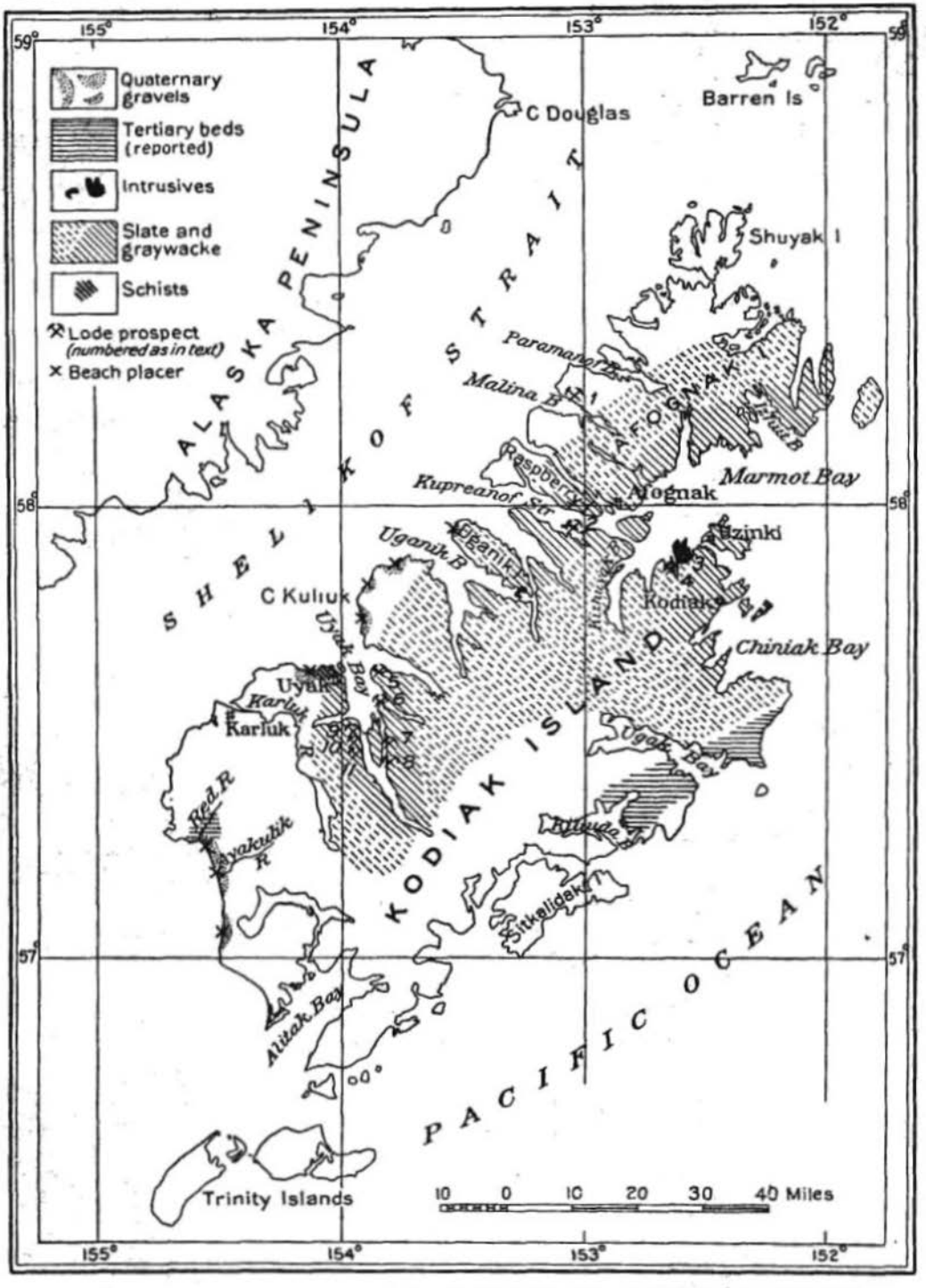
SCHIST.

The schistose rocks of Kodiak Island have been studied only on the northwest shore of the island between Uyak and Sevenmile Beach. It is considered probable that the exposures seen at this point are part of a general belt extending parallel to the northwest shore of the island and outcropping on most or all of the promontories.

These rocks include fine-grained quartzitic schist, crystalline limestone, and chloritic schist. They constitute a group of rocks of diverse lithologic character but of uniform degree of metamorphism and structural complexity. The thickness of the group and of its various members and the stratigraphic relations existing between the members have not been determined.

The associated rocks are cherts and lavas, presumably of Triassic age, and graywackes and slates. The relation of the metamorphic rocks to the associated sedimentary and volcanic rocks is not known.

No evidence as to the age of these schists has been obtained. They are presumably older than the associated Triassic (?) rocks and bear a close resemblance to the more highly metamorphosed rocks of Seldovia Bay, which likewise occur in association with and in an uncertain relation to Triassic cherts and lavas and Mesozoic or older



GEOLOGIC RECONNAISSANCE MAP OF KODIAK AND NEIGHBORING ISLANDS.

slates and graywackes almost identical in character with those of Kodiak Island.

SLATE AND GRAYWACKE.

Slate and graywacke are apparently the most widely distributed rocks on the islands. They compose the entire southeast shore of Afognak Island and the greater part of the northeast and northwest shores of Kodiak Island, and it is considered probable that they extend throughout the greater part of both islands.

These rocks consist of graywacke and slate in approximately equal amounts and in stratigraphic relationships which have not been made out. There are alternations of moderately thin beds of each kind of rock and also more massive aggregates of each kind. The stratigraphic relations of the aggregates to one another and to the alternating beds have not been determined. The presence of a subordinate amount of conglomerate is indicated by a few bowlders.

The slates and to a lesser degree the graywackes have a well-developed secondary cleavage which has thoroughly obliterated the bedding except where there is a well-defined change in composition.

The strike ranges from N. 3° W. to N. 75° E., averaging about N. 28° E. (magnetic), and the observed dips range from 20° to 80° NW., averaging about 56° NW. The structures are complex and are probably dominantly isoclinal. The structural details are not known.

The graywacke is composed of grains of quartz and fragments of shale, chert, oligoclase, albite, secondary sericite which was derived in part from feldspar, chlorite, and oxides of iron, in a fine-grained siliceous shaly matrix.

INTRUSIVE ROCKS.

The intrusive rocks consist chiefly of a large number of small dikes and sills, which are present throughout practically the entire area of the graywacke and slate. Larger intrusive masses were also seen east of Kizhuyak Bay and at the south end of Uganik Island. The coarser intrusive rocks include quartz-mica diorite and mica granodiorite. Quartz-mica diorite, porphyrite, and keratophyre were recognized among the small dikes.

Large areas of granitic rocks probably exist in the interior of Kodiak Island. A granitic mass which was not observed by the writer was described by Becker [1] as follows:

> The southern end of the ridge running along the westerly coast of Kodiak Island is called Saddleback and is granitic, and bowlders found on this coast seem to indicate that there is an area of the rock of considerable size. * * * A pebble or bowlder from the west coast of Kodiak is a normal muscovite granite. * * *

[1] Becker, G. F., Reconnaissance of the gold fields of southern Alaska: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 3, p. 36, 1898.

Intrusive rocks present in the vicinity of Karluk were described by Becker [1] as follows:

At Karluk, on the northwest coast of Kodiak Island, there are magnificent cliffs of an interesting hypidiomorphic diorite. The face of the cliffs * * * is partly gray and partly black, the two colors manifestly belonging to allied rocks which, however, are so mingled that it seems impossible to determine by mere inspection whether they represent successive intrusions, imperfectly separated masses, or a partial solution of one material in the other. The rock is extremely fresh and under the microscope is seen to vary in composition with the color. The gray rock is a quartz diorite containing hornblende, biotite, and labradorite. The analysis of this rock given below, made by Dr. W. F. Hillebrand, evidently answers to the composition ascertained under the microscope. The dark streaks and patches are more porphyritic than the gray portions just described. They consist of a peculiar reddish feldspar with the optical qualities of anorthite, embedded in a groundmass composed mainly of green hornblende, a little biotite, and quartz mingled with some feldspar. The microlites of the groundmass as well as the phenocrysts are anorthite. Needles of apatite and grains of magnetite are also present. The black diorite contains much more lime and much less soda than the gray material, as the partial analysis given below shows. Considering the relations of the chemical composition, it appears to me probable that the dark material in this diorite corresponds to the blebs so often found in granite and granodiorite, and that while the two materials have always been associated they have never been thoroughly mingled.

Analysis of Karluk diorite.

[By W. F. Hillebrand.]

	No. 213.	No. 211 (ferromagnesian facies).
SiO_2	61.58	54.26
TiO_2	.63	.....
Al_2O_3	15.89	.....
Fe_2O_3	2.19	.....
FeO	5.50	.....
MnO	.20	.....
CaO	6.49	8.88
BaO	.06	.....
MgO	2.69	.....
K_2O	.51	.64
Na_2O	3.04	1.99
H_2O below 110° C	.16	.....
H_2O above 110° C	1.26	.....
P_2O_5	.12	.....
FeS_2	.06	.....
	100.38	.....

TERTIARY ROCKS.

Strata of Tertiary age have been reported from several localities on Kodiak Island. As none of these places have been visited by the writer the following descriptions by Dall [2] are quoted:

Tertiary beds occur in various places on the islands of the Kodiak group, both of Kenai age and of the later Unga beds containing Miocene marine fossils.

[1] Becker, G. F., Reconnaissance of the gold fields of southern Alaska: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 3, pp. 41–42.

[2] Dall, W. H., Report on coal and lignite of Alaska: U. S. Geol. Survey Seventeenth Ann. Rept., pt. 1, pp. 800, 843, 1896.

On the island of Kodiak marine Miocene strata are found, and among the specimens brought back by Wossnessenski were clay ironstones containing plant remnants referable to the Kenai group. These stones were used by the native women for reddening the inner surface of dressed skins, and the only indication of locality for them is that they came from the northern part of the island. About the middle of the island, surrounding Ugak Bay, at the old settlement of Orlovsk, and on the north shore of Miliuda [Kiliuda] Bay next southward, and on the opposite side of the island, part of the shores of Uganuk Bay and of Uganuk Island in the bay, sandstones with lignite in thin seams overlain in places by marine sandstones like those of Unga, are reported on the authority of Kharitonoff and other Russians familiar with the island.

On the island of Kodiak, north of Tonki [Narrow] Cape, on the south coast from the shores of Igatskoi [Ugak] Bay, Wossnessenski collected a number of species of this fauna [of the "Astoria group"] which were embedded in a volcanic tuff about 10 feet above the sea. On the opposite side of the island, near the settlement of Uganuk, similar beds were found containing analogous fossils.

At the head of the bay into which Red River falls Messrs. Becker and Purington obtained specimens of Cardium, etc., in a brownish sandstone evidently belonging to the horizon of the Astoria Miocene.

QUATERNARY DEPOSITS.

The unconsolidated Quaternary deposits include glacial detritus, recent alluvial and beach deposits, and the covering of volcanic detritus which was deposited over much of these islands in 1912.

The glacial deposits are of wide extent, the entire area, except possibly the higher mountains, apparently having been overridden. The best observed development of these deposits is on the northwest shore of Kodiak Island both east and west of Uyak Bay. At Seven-mile Beach, west of Uyak Bay, a bluff about 60 feet high is composed of till. Similar bluffs occur between the entrance to Uyak Bay and Cape Kuliuk and probably at many other places.

The alluvial and beach deposits are of the same general character as those on similar streams and shores and call for no especial comment.

The volcanic deposits from the eruption of Mount Katmai in June, 1912, extend over all of Afognak Island and Kodiak Island as far west as Uyak Bay.

MINERAL RESOURCES.

GOLD LODE DEPOSITS.

KODIAK ISLAND.

The lode deposits of Kodiak Island occur as quartz veins in both the slaty and the granitic rocks. The slates and graywackes are almost everywhere cut by a multitude of minute quartz veins, which in various parts of the island attain considerable size and carry sulphides. No law regarding geographic distribution, relationship to lithology, structure, or intrusives has been established.

The older prospects on Uyak Bay were not examined by the writer, but they have been described by Becker[1] as follows:

Several small prospects exist on Uyak Bay, Kodiak Island. * * * The Bear, Dan, and Calaveras claims lie close together, the first two on what is supposed to be the same vein, and the last on a second, nearly parallel vein. The country rock is a carbonaceous schist or slate, and the fissures cut the cleavage. The Bear vein [No. 11, Pl. V] strikes N. 25° W. (true) and dips in a southwesterly direction at 40°. In width it varies from a few inches to about 6 feet and averages perhaps 2½ feet. The quartz is usually solid but is not entirely free from included schist fragments. A number of fine outlying parallel stringers accompany the vein. The sulphurets are arsenopyrite and pyrite, the former predominating. Free gold is easily panned from the croppings, and some extraction has been effected with an arrastre, but I was not able to ascertain yield or tenor.

The Dan [No. 10, Pl. V] is about 500 yards from the Bear and on its strike, but the deposit has not been traced through the heavy timber. The vein is about 2 feet in width and contains the same sulphurets. The mispickel here is well crystallized and the general appearance of the quartz is good. No work was in progress and scarcely any has been done. The Calaveras [No. 9, Pl. V] lies to the northeast of the Dan, on a similar vein of the same strike. It is about 20 inches wide and shows pyrite, mispickel, and galena.

The Lake claim [No. 6, Pl. V] is about 4 miles north of the Bear and on the east shore of the bay. The vein at this point strikes N. 70° E. (true) and dips 80° S., cutting the slate, which is here manifestly of sedimentary origin. The vein is only a foot wide, and the only sulphuret observed in it was a very little mispickel. This vein lies on one of a double series of joints forming a nearly rectangular system. On the shore below the vein is a neat illustration of the mechanism of jointing. The partings cross both sandstone and shale. In the sandstone the joints are from one-fourth to one-half inch wide and filled with quartz, but in the shale the same cracks are so narrow as to be scarcely visible, although sometimes carrying quartz. Evidently the shale yielded far more prior to rupture than did the sandstone.

The Wamberg and Boyer [No. 5, Pl. V] is 10 miles north of the Bear and near the entrance of Uyak Bay. The prospect is on a veinlet 7 inches wide, striking N. 55° E. (true) and dipping 65° SE. It lies in sedimentary schist and conforms nearly in strike, less nearly in dip. Near by excellent glacial modeling and scratches were observed.

The prospects of the Amok Gold Mining Co. and associated properties are situated on the east shore of Uyak Bay, east of Amok Island (No. 7, Pl. V). Several quartz veins, all of which are reported to be gold bearing, cut the country rock, which is black slate having a well-defined cleavage. The general strike of the cleavage is N. 15 °E. (magnetic) and the dip is 75° NW. The bedding of the slate is much disturbed and difficult to recognize, but at one point a strike of N. 35° E. (magnetic) and a dip of 47° NW. were observed. A small intrusive mass of sill-like habit cuts the slates. This rock was determined as keratophyre.

The principal vein outcrops approximately parallel to the shore, striking N. 45° W. (magnetic) and dipping 80° SW. It is said to

[1] Becker, G. F., Reconnaissance of the gold fields of southern Alaska: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 3, pp. 80–81, 1898.

average 3 feet thick with a maximum of 5 feet and is composed of quartz with a small proportion of pyrite, no other constituents being visible to the naked eye. The number and persistence of the larger veins are uncertain, but the slates are cut by a multitude of minute quartz veins, some of which pass into zones of multiple fracturing in which there are aggregate bodies of quartz of considerable magnitude. Most of these minor veins are parallel to the cleavage, though a few cut across it at various angles, some of which are as great as 90°.

The underground developments consist of an adit 210 feet long, a shaft 130 feet deep, two drifts 130 and 50 feet in length, and several surface prospects. Two mills of 5 and 10 stamps, respectively, several hundred feet of pipe line furnishing water under high pressure for power, and other outside improvements have been installed. The mills have not run yet.

A quartz vein outcropping on the beach near the present workings of the Amok Gold Mining Co. was mined by Mr. Wanberg several years ago. It is said that he took out about $8,000 in three or four years with an arrastre.

Matson's ledge is about one-half mile south of the Amok Gold Mining Co.'s property (No. 8, Pl. V) and consists of a 6 to 10 inch quartz vein striking N. 55° W. (magnetic) and dipping 60° SW. The country rock is slate and fine-grained graywacke, whose bedding (?) or cleavage strikes N. 10° E. (magnetic) and dips about vertical. A short adit and several open cuts were the only improvements seen on this property.

The Bear mining claim is situated one-half mile south of the head of Womans Bay, or 5 miles west of Uzinki, at an elevation of about 740 feet (No. 3, Pl. V). The ore body is 4 feet 2 inches wide at the surface and trends N. 60° W. (magnetic). The ore consists of pyrrhotite with considerable amounts of sphalerite and very small quantities of chalcopyrite. The only gangue mineral noted is quartz. Both walls are of mica granodiorite, locally known as granite, which is the only rock noted in the vicinity.

Several other prospects are situated in the vicinity of the group of islands at the mouth of the easternmost arm of Kizhuyak Bay (No. 4, Pl. V). They are probably in or near the same large granitic mass described above.

AFOGNAK ISLAND.

At a prospect on Malina Bay, Afognak Island, there is said to be a quartz vein 14 feet wide carrying gold and a little silver. The vein is said to occur at the contact of slate with granite and diorite and to be cut by a porphyry dike.

According to information received from another source, an adit 140 feet long was driven several years ago on a gold and silver bearing

vein at the mouth of the second creek inside the entrance to Malina Bay on the north shore (No. 1, Pl. V). This locality may or may not be the same as that mentioned above.

GOLD PLACERS.

DISTRIBUTION AND CHARACTER.

Placer gold has long been known to occur in the beach gravels on the north and west coasts of Kodiak Island. These placers are not rich, yet they have yielded an amount of gold which is very considerable in the aggregate, probably running from $3,000 to $10,000 a year. The better known are those at Sevenmile Beach west of Uyak, those on Uganik Island, and those at various localities near Red River and elsewhere on the west coast of Kodiak Island. Those at Sevenmile Beach are the only ones which the writer has examined. Those on the west coast, which yielded most of the gold taken out in 1912, were examined by Becker in 1895.

Sevenmile Beach is situated on the stretch of coast between Bear Island and Rocky Point west of Uyak. It is a broad sand and gravel beach behind which are bluffs of till about 60 feet high. The beach sands at this locality have yielded a moderate amount of placer gold, most of which was obtained in a distance of about 3¾ miles along the shore. The greater amount of the gold was obtained near the base of the bluff and on a "clay bedrock" (till) which lies 1 to 6 feet beneath the surface. The pay streak, which was from 12 to 18 inches thick, is said to be now worked out. The gold was obtained mostly in sluice boxes, although some rockers were used. Nuggets worth as much as 25 cents were obtained. It is said that as much as $10 per day per man was obtained at the richer localties. The deposit is evidently a wave concentration from the glacial deposits which form the bluff.

The beach placers on the west coast of Kodiak Island were extensively worked during the summer of 1912. As the writer was unable to visit these localities the following description by Becker [1] is quoted:

> Gold washing was in progress during my visit to the western shore of Kodiak Island, at Portage River and Ayakulik River. The beaches here lie along a bluff averaging 50 feet or more in height, which limits an extensive grassy plain. This represents a very recent uplift, which has been general throughout western Alaska, elevating most parts of Kodiak, Chirikof, Tugidak, and other islands. The recency of the elevation is shown by the fact that the little streams draining the low, flat plateaus have made small progress in cutting back into the bluffs. * * * At the beach washing the bluffs as well as the beaches carry streaks of black sand, and those in the bluffs are said to be auriferous as well as those at tide level. The source of the gold is doubtless in the ranges which lie several miles to the east of the bluffs. Pebbles of granite and metamorphic rock are found on the shore and have accompanied the gold

[1] Becker, G. F., Reconnaissance of the gold fields of southern Alaska: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 3, p. 86, 1898.

from its original position. The gold-bearing sands do not occur in masses but in patches perhaps an inch in thickness and extending over a few square yards. When such a patch is found the material must be gathered and carried out of reach of the waves, which constantly shift the sands from place to place. The Kodiak sands consist of magnetite, garnet, quartz, slate, serpentinoid material, and very light scaly gold. The gold floats easily and does not seem to amalgamate well. No doubt much of it is lost, and some new process, such as cyaniding, must be adopted before large profits can be made from any but exceptionally rich beach sands.

Cliffs of unconsolidated deposits along much of the shore between Cape Kuliuk and the entrance to Uyak Bay resemble those back of Sevenmile Beach. They were not examined closely, but are believed to be of glacial origin. At other localities along the northwest coast of Kodiak Island placer gold has been found in most of the beaches lying at the base of low alluvial bluffs. A notable occurrence of this kind is at the western end of Uganik Island, where considerable amounts of gold have been taken out from time to time.

ORIGIN.

The important gold placers of Kodiak Island, so far as known, all occur where there is violent wave action, on cliffs composed of Quaternary deposits. The Quaternary deposits, which constitute the secondary source of the gold, are of local and not of widespread occurrence. All these Quaternary deposits (Pl. V) seem to lie at the mouths of valleys which terminate on the open coast and not at the heads of bays. Those at Sevenmile Beach consist of till. Some of the others, such as those on the west coast of Kodiak Island and probably those between Cape Kuliuk and Uyak Bay, consist at least partly of stratified gravels. All are believed to be closely related to glaciation and to have been deposited either directly by glaciers which had their fronts near the present shore line or in waters which were ponded in the present mouths of the valleys by the large glacier that once flowed past the island. Recent earth movements may or may not have brought the deposits into their present position relative to sea level.

The ultimate source of the gold may have been either in the slates and graywackes, which are known to contain a multitude of small quartz veins, some of which carry gold, or in lode deposits occurring in rocks of possibly different character in the interior of the island. The former glaciation of the island makes it practically hopeless to attempt to trace the gold to its source.

The important fact to be considered in a search for workable deposits is that prospecting has hitherto yielded valuable placers only where active reconcentration of old gravels has taken place. The old gravels are of considerable volume, but are of local occurrence. They do not appear to carry gold in sufficient concentration to be worked,

but so far as known they have not been adequately prospected at their base nor in places where the richest concentration would be expected. The old gravels appear to have yielded valuable placers wherever they have been actively reworked, as by the waves, and it hence appears that gold is probably well distributed throughout them. Localities where these deposits have been reworked by active streams would appear to be worthy of prospecting. The streams which drain the known gravel areas are mostly small and probably have not accomplished any considerable amount of reconcentration.

COAL.

The only coal known on Kodiak Island is that near Red River, which was described by Dall [1] as follows:

Coal exists in a clay bank near the beach at Red River, Kodiak, of which a specimen was obtained by Dr. Becker and Mr. Purington. An analysis affords the following data:

Analysis of coal from Red River, Alaska.

Moisture	12.31
Volatile matter not moisture	51.48
Coke	33.80
Ash	2.41

The coke was sooty and noncoherent. The percentage of sulphur to the whole coal was 0.17.

The existence of coal is also known on Sitkinak Island, southwest of Kodiak, the following description being given by Stone: [2]

Coal occurs on the high island of Sitkinak,[3] one of the Trinity Islands, at the southern end of the Kodiak group. In the rocks which outcrop boldly on a lagoon on the northeast side of the island there are a number of seams of coal, one of which is said [4] to be 10 to 12 feet thick, standing vertically in a bluff 20 feet high. The deposit is somewhat limited in extent. Some schooners have sometimes visited this locality to get a boatload of coal, which can be obtained handily from the beach. It makes steam readily but is inconveniently situated for access by large vessels. The almost constantly raging surf beating around the shallow coast is a serious obstacle.

Stone [5] also quotes Francis to the effect that the Tertiary rocks at Kiliuda Bay contain two coal beds, probably 6 to 8 inches thick.

[1] Dall, W. H., Report on coal and lignite of Alaska: U. S. Geol. Survey Seventeenth Ann. Report, pt. 1, p. 800, 1896.

[2] Stone, R. W., Coal resources of southwestern Alaska: U. S. Geol. Survey Bull. 259, p. 163, 1905.

[3] Alaska Eleventh Census Rept., p. 78, 1893.

[4] Information from P. W. Francis, of Seattle.

[5] Op. cit., p. 163.

LODE MINING NEAR FAIRBANKS.

By PHILIP S. SMITH.

INTRODUCTION.

The inevitable depletion of easily mined placer deposits near Fairbanks and the consequent availability of both men and money for other enterprises has given an impetus to prospecting for lode deposits which has resulted in the opening of some productive mines. The writer visited the lode-mining district late in the open season of 1912 to study the conditions under which the veins occurred, and the results of that study are set forth in the accompanying report. Work in the field began September 7 and closed September 25, 1912. In spite of this short season the studies by Mr. Prindle and Mr. Katz furnished geologic data so complete that the investigations here recorded were devoted exclusively to mining developments.

The writer is under deep obligations to both Mr. Prindle and Mr. Katz not only for their published data but also for the assistance they have given by consultation and advice. Grateful appreciation of the many courtesies and privileges received in the field is expressed to the various mine owners, operators, and residents of the Fairbanks region. Although specific mention is necessarily incomplete, thanks are especially due J. L. Sales, of Fairbanks; the Cook brothers, of Too Much Gold Creek; the members of the Rexall Mining Co., of Wolf Creek; Nels Giske and the Quemboe brothers, of Chatham Creek; Allan Cunningham and Antone Goessmann, of Bedrock Creek; C. S. Sargent, of Willow Creek; Sterling, Zimmerman, and Nightingale, of Twin Creek; W. L. Spaulding, of Dome Creek; and W. C. Harp, the Hudson brothers, and Louis Sagan, of Ester Creek.

GENERAL GEOLOGY.

The following summary of the bedrock geology of the Fairbanks district has been abstracted from a report by Prindle and Katz which should be consulted for more detailed descriptions.[1] The unconsolidated deposits have not been discussed here, as they have little or no bearing on the subject of the present report.

[1] Prindle, L. M., and Katz, F. J., Detailed description of the Fairbanks district: U. S. Geol. Survey Bull. 525, pp. 59-77, 1913.

The greater part of the bedrock of the Fairbanks district is formed of metamorphic rocks which have been grouped together and called the Birch Creek schist. These rocks include rather massive quartzites, quartzite schists, quartz-mica schists, hornblende schists (in part amphibolitic), carbonaceous schists, crystalline limestones, and altered calcareous rocks, with associated eclogitic rocks, andalusite hornfels, and a small amount of granitic gneiss derived from porphyritic intrusive granite.

All of these rocks are closely folded. Recumbent minor folds are common, and so far as observed the direction of overturning is toward the northwest. In places the folding is so close that the limbs are nearly parallel and cleavage and bedding planes become also parallel. The dips, therefore, indicate rather the dip of the predominant structural planes, which may or may not be the true dip.

The Birch Creek schist is unfossiliferous and its age has not been definitely determined. The earliest fossils found in passing from it into the overlying rocks in other parts of the Yukon-Tanana region are Ordovician in age, and therefore possibly the Birch Creek schist is in whole or in part Cambrian.

The igneous rocks of the Fairbanks district include several varieties of intrusive granular rocks and a small amount of igneous material regarded as extrusive. Intrusive granular rocks that penetrated the schist at such depths below the contemporary surface of the earth as to have cooled with sufficient slowness to become entirely crystalline are separable into quartz diorite, porphyritic biotite granite, light-colored persilicic granitic dikes, and altered porphyritic dikes related to granitic and dioritic rocks. All these have been shown on the map (Pl. VI) in one pattern.

The greater part of the intrusive rocks of the Fairbanks district belong to the granite and diorite group. The quartz diorite of Pedro Dome and the porphyritic biotite granite of the Smallwood-Gilmore ridge are distinct types, but there are several intermediate phases. Although the coarse porphyritic biotite granite was nowhere observed cutting the quartz diorite, fine-grained dikes like those which cut the biotite granite and which are closely related to it in composition and were only shortly subsequent to it in time of intrusion were observed to cut also the quartz diorite. Both the two main types are probably the products of the same general period of intrusion. The sericitized dikes of granite porphyry and quartz diorite porphyry are probably to be referred in origin to the main intrusive masses and have been in part altered by hydrothermal action. Passageways for various after-products of intrusion were afforded by an extensive shattering that took place in part at least subsequent to intrusion.

No definite age can be assigned to these intrusives. Conglomerates regarded as Tertiary contain numerous bowlders of granite whose ori-

gin is not definitely determined, but from what is known of Tertiary deposits in other parts of the Yukon-Tanana region probably these conglomerates are of Kenai age, which indicates that the granitic intrusion was earlier than the Kenai epoch. The nearest similar intrusive rocks whose age of intrusion is rather definitely known are those of the Rampart region, 90 miles to the northwest, which have intruded Upper Cretaceous rocks.

PRESENT CONDITION OF LODE MINING.

GENERAL FEATURES.

In the region adjacent to Fairbanks 2,000 lode claims have been recorded and of these probably 50 are being more or less extensively prospected. Practically all the veins that are being developed are free milling gold lodes, as deposits of this or other metals requiring metallurgical treatment for extraction can not be mined under existing conditions. Six of the properties have been developed to the producing stage and maintain their own mills. Six other mills are being constructed and should be in operation before the end of 1912, and still others are contemplated.

The six mills now in operation have a total of 24 stamps, of which 22 are of the Joshua Hendy type (fourteen 1,000-pound stamps; five 500-pound stamps, and three 250-pound stamps) and two are Nissen stamps of 1,300 pounds each. These stamps have an estimated crushing capacity of 1 to 5 tons of ore a day. Of the mills being built, two are to be equipped with seven stamps of the Hendy pattern, three with six Nissen stamps, and one with a Little Giant crusher having an estimated capacity of 6 to 15 tons of ore a day. According to these estimates the mills should be capable of crushing about 100 tons of rock a day.

According to Brooks[1] about $64,100 was produced by the lode mines in 1911 and about $60,000 had been produced previously. No reliable statements of the gold production from the lodes in 1912 have been received, but it is estimated to have been about $200,000. The discrepancy between this estimate and the amount that should have been produced as indicated by the theoretical capacity of the mills and the assumed tenor of the ore is due to three main causes, namely, many of the mills were built during the year and therefore lost more or less time on that account; few of the mines have been opened up sufficiently to yield a constant supply of mill rock; and many of the mills have been compelled to close down during the winter on account of the cold.

The trouble with cold is serious and is felt most acutely in its effect on the water supply. It is relatively easy to keep a mill so

[1] Brooks, A. H., The mining industry in 1911: U. S. Geol. Survey Bull. 520, p. 30, 1912.

warm that water will not freeze in the mortars or on the tables, but the cutting off of practically all sources of surface water during the six or seven winter months presents an almost insuperable difficulty. The larger streams, of course, afford ample water throughout the year, but these are at some distance from the mines and selection of a mill site on them involves additional charges for the transportation of ore. Attempts to gain a sufficient permanent water supply by boring holes a hundred or more feet in depth have so far met with indifferent success. At a few places seepage water pumped from the mine has been used at the mill, but the supply has not been adequate. In fact, one mill where this was tried was forced to abandon the experiment and was moved near to a creek at a considerable distance from the mine.

On the whole the camp has shown a rather healthy development, with less exaggeration and wildcatting than has been customary elsewhere. Most of the veins have been and are being opened by local men and capital, and some of the most productive have been made to pay from the start. In general this quiet, relatively inexpensive exploitation of the lodes has been beneficial, but the camp has had the disadvantage that many of the operators are not lode miners and consequently have made mistakes that might have been avoided. The need of proficient engineers and miners is already felt by the more enterprising operators and will become more urgent as mining increases. As a result of the absence of skilled management none of the mines employ the careful methods of sampling, investigation of mining costs, scrutiny of geologic data, and precise measurements that are necessary to reduce mining from a speculative venture to a more or less exact business enterprise.

LODE MINES AND PROSPECTS.

GENERAL DISTRIBUTION.

During the six or more years that prospecting for quartz has been in progress in the region a great number of prospect holes have been sunk. Many of these, for one reason or another, have been abandoned and their traces are no longer recognizable. In places, however, information about some of this old work was obtained from people living in the neighborhood, and such of this as appears reliable has been presented in this report. In the following descriptions many details concerning small and nonproducing properties have been given because they afford information as to the geologic history, mode of occurrence, and distribution of the veins. These descriptions, therefore, should be regarded not only as records of facts but also as clues to the character of deposits not yet exploited.

All parts of the area have not been treated with equal completeness, and some small prospect holes that were actually examined are undoubtedly described more fully than possibly extensive prospects that have been abandoned. Although there are many reasons for a good prospect lying idle, on the whole, other things being equal, the fact that no work is in progress on a certain property indicates that it is not so important as one on which work is in progress. Therefore the map (Pl. VI) indicates, by the distribution of the prospect and mine symbols, the most developed lode area. This map shows that most of the prospects occur near the head of Fairbanks Creek, on many of the headwater branches of Cleary Creek, at the head of Dome Creek, on Twin and Skoogy creeks, and in the vicinity of Ester Dome, in the extreme western part of the district. The prospects in each of these areas will be described in the order of their geographic positions in their minor basins. Mineralization has been found and prospecting carried on not only in these main areas but at a few other places, which have been described under the general heading "Miscellaneous prospects." (See p. 196.)

TRIBUTARIES OF FISH CREEK.

FAIRBANKS CREEK VALLEY.

EAST OF MOOSE CREEK.

The most eastern prospect noted in the Fairbanks Creek region is the Charles claim, near the head of Walnut Creek, which rises on the southwestern slopes of Coffee Dome. No work was in progress on this prospect in 1912 and it was not visited. Brooks,[1] however, states that in 1911 an 18-inch ledge of ore was reported on this claim, some of the vein material from which was milled at Chena. No data were furnished as to the amount of development work or the tenor of the ore.

Prindle [2] reported in 1909:

> At the head of Alder Creek, a tributary of Fairbanks Creek, at the [Dan] McCarthy property, including the Lime, Lemon, and North Star claims, is a vertical quartz vein striking about N. 40° E. and 12 to 13 feet wide. A tunnel has been driven parallel to the vein for about 120 feet and the lode has been crosscut at a depth of 50 feet. Along the margin of the vein and along the horses of schist that are found in it there is considerable mineralization and some values are reported. Two other similar quartz ledges parallel the one described, but had not been opened in 1909. The vein quartz of these localities is much fractured and the mineral-bearing solutions have apparently been introduced subsequent to the fracturing.

[1] Brooks, A. H., The mining industry in 1911: U. S. Geol. Survey Bull. 520, p. 31, 1912.

[2] Prindle, L. M., Auriferous quartz veins in the Fairbanks district: U. S. Geol. Survey Bull. 442 p. 227, 1910.

Brooks notes that in 1911 a 50-foot shaft showing 3 feet of ore was said to have been sunk on the Eureka claim and some of the ore milled at Chena. In 1912 the Alder Creek localities were not visited, as, according to report, no mining was then in progress.

MOOSE CREEK.

Some prospecting has been done in the basin of Moose Creek on the western hill slope. The greatest amount of work has been done by Crites and Feldman, who have located several veins and have sunk a number of prospect pits all the way from a point at an elevation of 1,525 feet near the creek to a point on the divide between Too Much Gold and Moose creeks, at an elevation of about 2,150 feet. (See fig. 1.) The general trend of the line of pits is N. 65° W., but as the vein has been faulted this direction is not the actual course of the veins. The veins are from 1 to 3 feet wide. They cut across the lamination of the schist and stand nearly vertical. At an elevation of about 2,100 feet west of Moose Creek the main or southern vein appears to split, giving off a spur vein trending more nearly east and west. The southern vein is composed mainly of quartz and a small amount of stibnite and numerous particles of visible free gold. Near the junction of the northern and southern veins a large amount of stibnite forms a lens, in places over 3 inches thick, of well-crystallized stibnite, practically unmixed with other sulphides. At an elevation of 2,050 feet another vein, trending about N. 15 E. and dipping west, has been traced northward for a short distance, but its gold tenor was so low that work on it was abandoned.

The vein material from the southern lead is mainly a light-colored, glassy quartz, somewhat crushed, but showing in places druses into which well-formed crystals of quartz project. On exposed surfaces the quartz has a brown iron stain, but more commonly it is characterized by a greenish-yellow color, due to the decomposition of stibnite. Here and there sulphides and visible gold occur in the quartz, but the amount of sulphides is small, on the average being much less than 5 per cent of the vein material. Although stibnite is the most abundant of the sulphides recognized at this place, argentiferous galena occurs sparingly and also some arsenopyrite, pyrite, and sphalerite. In many specimens the stibnite near the surface has been altered into the antimony oxide, senarmontite. This mineral is particularly abundant in the spaces between the quartz grains.

The gold appears to be entirely native but occurs in two main modes. In one it is closely associated with the sulphides and appears to have been essentially contemporaneous with their deposition; in the other it does not seem to have been formed with the sulphides but occurs instead in the midst of the earlier-formed quartz. Even in specimens of quartz containing no gold that is visible to the

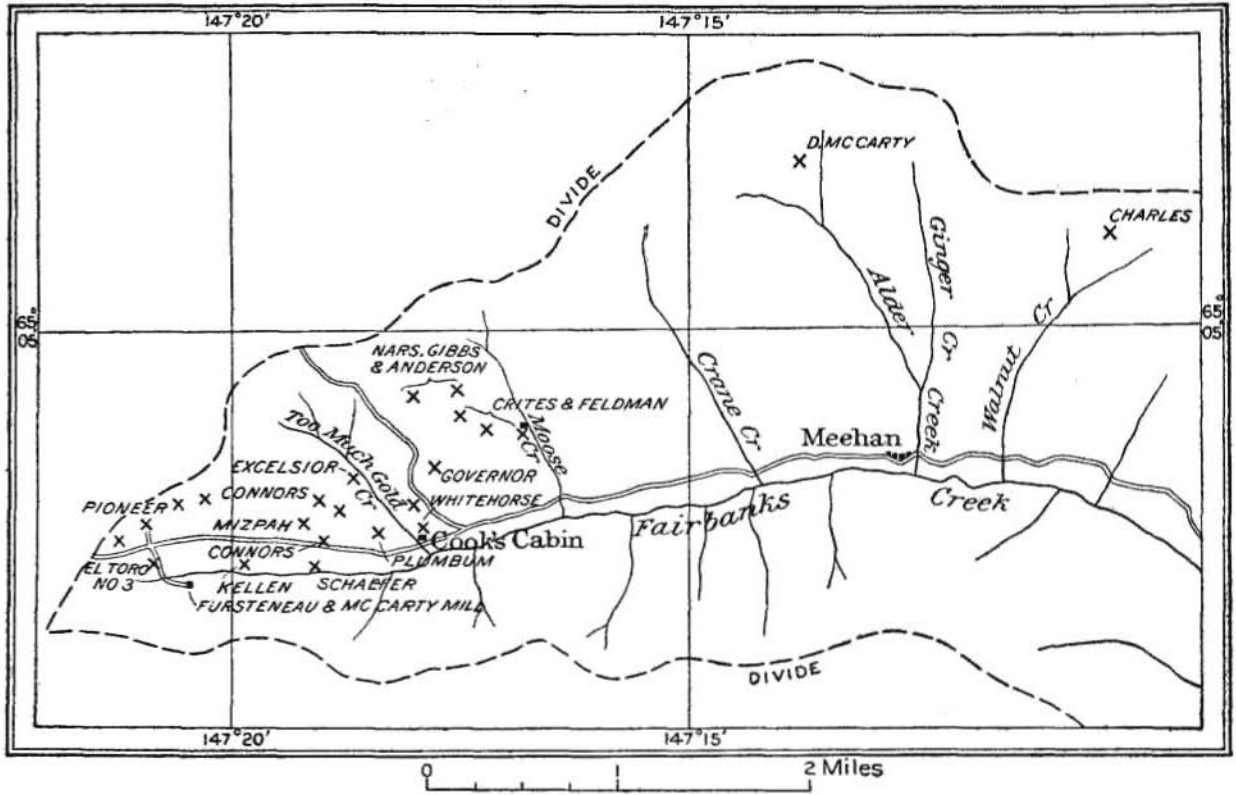


FIGURE 1.—Sketch map showing location of lode prospects in Fairbanks Creek valley.

unaided eye and no sulphides, small colors of gold may be found by panning the finely crushed vein material. Although the gold content of some of the surficial portions of the veins may have been increased by secondary enrichment, the larger part of the auriferous content is probably original and is an integral part of the vein. These veins have not been accurately sampled, and estimates of the tenor of material carrying so much free gold are of little value. The ore, however, is reported to contain from $50 to $75 a ton in gold.

Surface prospecting has been the only work yet done on the property, but the owners propose driving an adit northwestward from a point near the vein outcrop on Moose Creek. As the valley walls are rather steep, a considerable back of ore would be obtained above the adit level; thus in a horizontal distance of 1,000 feet the back would be nearly 300 feet.

About 200 yards above the Crites and Feldman cabin two shallow prospect pits have been sunk by another prospector. The schist exposed in these pits is heavily iron-stained, but in the lower hole no distinct vein was disclosed. In the upper hole, however, some quartz in irregular stringers was found, and a good deal of arsenical pyrites mineralized not only the quartz but also the adjacent schist. This material is said to yield gold on panning, but none was visible in the hand specimens examined. No ore from this property had been milled.

TOO MUCH GOLD CREEK.

At the head of Too Much Gold Creek, at an elevation of about 2,225 feet (see fig. 1, p. 143), Nars, Anderson & Gibbs have done considerable development work on a vein that appears to be the same as or parallel to that of Crites and Feldman, on Moose Creek. The main vein has been traced by surface pits eastward to the limits of the claims. A smaller vein parallel to the main lead has been found, but has not been so fully opened up. The main vein is from 6 inches to 2 feet wide, though in a few places, owing to mineralization of the wall rock, a width of probably as much as 6 feet can be profitably mined. The dip of the vein at the surface is about 65° N., but it is said to steepen in depth.

The ore is essentially the same as that of the Crites and Feldman veins, already described, but contains somewhat less stibnite. The contact of the vein with the country rock on the hanging wall is marked by a smooth fault plane. Where the vein and country rock come to this plane their surfaces are strongly slickensided and polished. Some of the sulphide mineralization was earlier than this faulting, for the sulphides have been spread out and striated by the movement. On the footwall the vein, in its surficial portion, is frozen to the country rock, and although the junction between the

two is rather sharp, there is an intermingling of the ore and schist that differs notably from the abrupt transition on the hanging wall. The air in the shaft was too bad to permit the vein to be examined in depth, but the operators report that at 80 feet below the surface the footwall becomes smoother and the ore breaks away from the country rock better, which suggests that at depth the footwall may also mark a plane of movement.

The main underground development at this place has been the sinking of a 100-foot incline on the vein, from which short drifts, 15 and 25 feet in length, have been turned off at the 60-foot level. There has been no trouble with water, but the air has been so bad, possibly from the arsenical iron in the ore, that further sinking was abandoned until artificial ventilation could be provided. A small hoist and boiler have been installed at the shaft, and the owners plan to continue mining during the winter of 1912–13. Several mill tests of the ore made at Fairbanks are said to have yielded returns of about $60 a ton. Two and one-half tons were milled in the winter of 1911 and 4 tons in the spring of 1912, and about 2½ tons are sacked on the dump, ready for treatment.

On the ridge between Too Much Gold and Moose creeks, below the veins already described, there are several other prospect pits. At an elevation of 1,850 feet at a place nearly due north of the junction of the creek with Fairbanks Creek, on the Governor claim, a 70-foot shaft had been sunk on a vein trending N. 80° W. and dipping nearly vertical. The ore in general appeared similar to that from the veins already described, but in addition included a light-colored fine-grained rock, probably a fine-grained granite, that is said to carry from $10 to $15 a ton in gold. This rock contains many small vugs, which appear to have been formed by the leaching out of sulphides. Much of the ore has been strongly slickensided. At this shaft there is no permanent equipment, and no work has been done for some time.

At a point east of the Governor claim, at an elevation of about 1,600 feet, a ledge which may be the continuation of the Governor lead was reported to have been found, but at the time of the writer's visit it had not been opened up enough to allow adequate examination.

At an elevation of 25 feet above Cook's cabin, east of Too Much Gold Creek, some ore has been taken from a pit 18 feet deep. At the time of the writer's visit about half a ton of this ore had been sacked and was on the dump awaiting treatment. The footwall at this place is a much-brecciated mass of rock of unknown extent, cemented together by iron, stibnite, and galena. This mineralized mass is believed to be entirely distinct from and younger than the

auriferous vein near by, for it apparently contains fragments of the vein. The brecciation and mineralization at this place may have been produced by igneous intrusion, for an open cut at an elevation of 25 to 50 feet above the pit where this rock occurs contains float of a white porphyritic granite. So far as determined, however, the granite is not noticeably mineralized. The hill slopes near this place are too much covered with talus and turf to permit a determination of the direction or extent of the granite, but the men who have done most of the prospecting say that they have found several dikes here, one as much as 70 feet wide, which are more or less parallel with the larger quartz leads.

West of Too Much Gold Creek several claims have been prospected. (See fig. 1, p. 143.) On the Plumbum claim, which is the nearest to Fairbanks Creek, a quartz vein ranging in width from 3 inches to 2 feet has been exposed in a test pit 15 feet deep. The country rock is schist, striking nearly east and west, and dipping south at a low angle. The vein has nearly the same trend as the schist, but its dip is much steeper. The schist carries, in addition to the vein, which sharply cuts it, numerous quartz lenses, which are entirely distinct from the vein and are cut by it. The vein is composed mainly of a brownish-white, somewhat crushed quartz showing a few open spaces, practically barren of sulphides, and heavily iron stained on its upper surface. Some highly crystalline parts of the vein may, however, have been formed by later fracturing and infiltration. The well-formed quartz crystals in these crystalline parts are generally coated with iron oxide, which may have been derived from the decomposition of sulphides that were originally present in this more porous portion.

The westward continuation of this lead has been sought by sinking prospect holes along the ridge. Quartz veins have been exposed in many of these holes, so that the same or parallel leads have been found nearly to the limits of the claim. Several nearly vertical faults parallel to the vein were found in these pits, but the amount of displacement to which they gave rise was apparently slight. Faults transverse to the vein were not observed, but the failure to note them may have been due to the small extent of rock exposed, as the alignment of the pits suggests that the vein is not continuous. No production has been made from this claim, but about 1½ tons of ore are sacked on the dump awaiting shipment.

Farther up Too Much Gold Creek, on the Excelsior claim, at an elevation of about 1,625 feet, near the stream, two adits have been driven westward. The southern adit follows a small seam that dips steeply south. At a distance of 60 feet from the mouth of this adit a short drift has been turned off to the south on a small stringer that trends nearly north and south. The country rock is hard quartzitic

schist that dips at a much lower angle than the vein. Near the mouth of the northern adit the same kind of schist occurs, but farther in the adit it is succeeded by soft black shiny graphitic schist which in places is said to yield high silver assays. Specimens of this ore examined in the laboratory showed a small amount of sulphides—galena arsenopyrite, and stibnite—but the material does not appear to be much mineralized. This adit is about 60 feet long.

Near the Excelsior adit is an exposure of a light-gray fine-grained granitic rock containing small, irregularly distributed cavities surrounded by limonitic rings. This rock is considerably iron stained on its exposed surfaces but contains no visible metallic minerals. It has a fine-grained groundmass, mainly quartz and feldspar, through which quartz phenocrysts are scattered. This rock and the veins prospected on the Excelsior claim lie so close together at the surface as to suggest that they are genetically related, but the surface exposures are so small that such a relation can not be demonstrated.

On the hillside above the Excelsior adit numerous pits have been sunk on a vein called the "cross vein," which trends about N. 30° E. and dips southeast at a high angle. Most of the pits have caved to such an extent that the character and width of the vein is not determinable. On the whole, however, this vein appears wider than the east-west veins already described and contains rather more sulphides. These veins are currently reported to carry considerable silver, but specimens collected by the writer have not yielded any of this metal. The dark mineral probably confused with silver is, in every specimen so far examined, galena, stibnite, or arsenopyrite.

The N. 30° E. vein just described intersects an east-west vein which has been opened up on the Mizpah claim on the ridge between Fairbanks and Too Much Gold creeks, at an elevation of about 1,700 feet. The contact between the two was not well exposed, but prospectors report that the two merged—that one did not cut the other.

WEST OF TOO MUCH GOLD CREEK.

The Mizpah vein, staked in 1910, is north of Fairbanks Creek about half a mile west of the mouth of Too Much Gold Creek, at an elevation of 1,800 feet. The vein strikes about east and west and dips more than 75° S. It has been developed by a shaft 120 feet deep, from which drifts have been turned off both to the east and to the west at the 80-foot level. No difficulty with water has yet been experienced. In the western drift numerous well-defined stringers composed mainly of quartz, with subordinate amounts of sulphides, carry free gold, apparently as an original constituent. The quartz has a sliced appearance, as if the vein had been subjected to considerable movement. In the eastern drift the vein made a slight roll, so that for a while it appeared faulted, but further work showed that

it persisted in the hanging wall. On the foot-wall a gouge a few inches thick, said to prospect well, probably marks a zone of movement.

The minable rock at the Mizpah claim ranges in thickness from 12 inches to 3 feet, the average being about 2 feet. A test of about 3 tons of ore at the Fairbanks mill is reported to have given a return of $92 a ton. This, without doubt, was selected material, so the test only shows that some of the ore is of high tenor. Little work is now in progress at the property. Plans are said to be under way for building a mill, but it will probably not be constructed until the mine is further opened, and this delay is advisable not only to determine whether a mill is warranted, but also to provide a sufficient reserve to keep it running.

Between the Mizpah shaft and Too Much Gold Creek are the Ohio and Mayflower claims of Connors & Stevens. The upper shaft, at an elevation of about 1,900 feet, is said to have been sunk about 45 feet. It opens up a vein that trends about northeast-southwest. The shaft was not accessible at the time of the writer's visit, but the country rock on opposite sides of the vein is reported to be dissimilar, which suggests that the vein occupies a fault plane. Specimens of the ore on the dump contain a large quantity of sulphides, notably galena and stibnite, associated with quartz. The quartz is sheared and many of the shearing planes exhibit sulphides or their oxidation products. In addition some quartz was apparently deposited contemporaneously with the sulphides and forms long hexagonal crystals in the midst of the galena.

The southern shaft on the Connors & Stevens property is near the road, at an elevation of about 1,675 feet. At this place there are two veins which are about 4 feet apart at the surface but more than 15 feet apart at the bottom of the shaft. The veins strike about northwest-southeast, but their direction is locally variable. The walls show strong slickensiding with striæ running practically vertical and the southern block relatively downthrown. The ore on the footwall merges into the schist, but that on the hanging wall abuts directly against the fault plane. No adequate measurement of the amount of displacement was obtained. About 15 feet above the bottom of the shaft a winze has been sunk to the northeast, at a low angle, on a stringer of ore which has been traced about 25 feet.

The tenor of the ore has not been tested by mill runs, and the few assays that have been made show a variation so great that they are of no service in estimating the average of the mine. The owners believe that the average value of the ore is at least $50 a ton, mostly gold, but partly silver.

On Fairbanks Creek, just below Connors & Stevens's prospect, is a short tunnel trending about north and south. At its mouth is a small amount of mineralized quartz, and beyond is graphitic quartzose

schist which dips northward at a low angle. The schist is reported to have yielded 60 ounces of silver and $4 in gold to the ton, but no indications of a silver-bearing mineral were seen. The quartz stringers are said to carry about $4 a ton in gold and no silver, but this tenor is too low for profitable mining.

A short distance upstream from this tunnel is another, driven by M. A. Schaefer, about 150 feet long, trending N. 5° E. In the breast is a rather flat-lying quartz stringer. Its position is unusual, for in general the veins are steep and the country rock is fairly flat, whereas at this place the situation is exactly the reverse. The tunnel is so near the surface, even at its inner end, that the rock is greatly decomposed and strongly iron stained. No production has been made from this property and no reliable estimate has been made of the tenor of the ore.

Half a mile above M. A. Schaefer's, on Fairbanks Creek, is Kellen's property, which has been prospected by a shaft and tunnel. The tunnel has been driven 80 feet northward on blocky schistose quartzite that dips south at an angle of 60°. Some quartz stringers said to carry gold were intersected by the tunnel, but they are too small to be mined independently and their tenor is too low to permit much country rock to be mined with them. A reddish iron-stained seam at the face of the tunnel dips steeply to the north and suggests that the vein is near, but does not seem to be the lead encountered in the shaft above. The shaft was sunk just above the north end of the tunnel and uncovered a narrow lead of crushed and recemented quartz having somewhat the texture of a quartzite. Long cavities in the vein appear to have been formed by the leaching out of a striated bladed mineral, such as stibnite. Stibnite in irregular patches is fairly common throughout the quartz and shows the usual oxidation stages to senarmontite or has even been completely removed, if the cavities noted above were really formed by the leaching out of this mineral. No ore has been produced at this property and work has been carried on only at intervals.

At the extreme head of Fairbanks Creek are a number of leads, and the ground has been blanketed by rival claimants and tied up with lawsuits. In consequence the ownership of the several properties is uncertain, and until the courts act many of the claims have two or more names. Without expressing any opinion on the issues raised by the litigation, certain claim names have been adopted here solely for convenience in description.

Between the road and the head of Fairbanks Creek, at an elevation of 2,150 feet, is "El Toro 3" claim. It has been developed by a 65-foot inclined shaft sunk on the vein. Near the surface the dip of the vein is 72°, but lower down it flattens to 51°, and continues on this slope to the bottom of the shaft. The vein matter consists almost

entirely of hard, rather glassy quartz, with a small amount of stibnite. The quartz is said to carry native gold, which is practically invisible until the ore is crushed and panned. No production has been made from this claim.

North of "El Toro 3," trending nearly east and west, five claims, named in order from west to east the War Eagle, the Leroy, the Pioneer, the Iron Mask, and the Black Warrior, extend between the road and the top of the ridge. The veins found on these claims have not yet been traced accurately, but they are all essentially contemporaneous and form a parallel series, having a nearly east and west strike and a dip of over 45° S. In physical appearance the vein matter from the different leads is practically indistinguishable, and, so far as determined, the gold tenor does not vary more in the different veins than it does in different parts of a single vein.

On the westernmost claim two leads have been found in five or six pits from 8 to 10 feet deep. The veins are 1 to 2 feet wide, and many pieces of the ore show free gold. On the next claim east two shafts have been sunk on a vein believed to be the continuation of one of the veins on the western claim. At this place the vein is about a foot wide. Little development work has been done on this lead.

Still farther east, on the Pioneer, the most extensive work on this group of claims has been done. Here a shaft 110 feet deep was sunk and the vein was drifted on both east and west for about 200 feet. East of the main shaft another, 75 feet deep, was put down and 50 feet of drift was driven eastward. About 75 feet east of this last shaft another, 38 feet deep, has been sunk. Still farther east pits 10 to 15 feet deep have been put down at intervals of 25 to 50 feet, and a lode has been uncovered. The vein is reported to have been proved in this manner for 800 feet, in which distance it shows an average width of about 18 inches. Gouge from 6 inches to a foot thick occurs on both walls.

A lode 3 feet wide has been uncovered just east of the Pioneer and is now being developed on a lease. On the hanging wall of the vein at this place is a white, thoroughly decomposed rock which appears originally to have been a fine-grained granular intrusive, but which is now a gritty gray mass of kaolin and quartz, the quartz occurring as irregular small particles in a groundmass of kaolin and finely crushed quartz. The underground workings at this place were inaccessible at the time of the writer's visit, owing to a cave-in, but this decomposed material is said to give place in depth to quartz carrying gold, a condition that seems doubtful, as a faulted relation between the two is more probable.

Still farther east, on the last claim of this group, a vein is said to have been traced for 400 to 500 feet by test pits, 12 to 15 feet

deep, sunk at intervals of about 50 feet. On this claim the vein averages from 8 to 10 inches in width.

In 1912 none of these properties were producing ore, but according to Angus McDougall, one of the owners, 107 tons have been mined and milled, mainly from the Pioneer property. Of this amount 22 tons is said to have yielded a return of $172 in gold to the ton, not including concentrates, and the rest carried from $125 to $150 a ton, also not including the concentrates. About 65 tons of ore are sacked on the dumps awaiting treatment. The owners estimate that this lot will yield about $65 in gold a ton. According to Frank W. Hawkins, formerly assayer for the Washington-Alaska Bank, the average fineness of the gold bullion so far received from this mine is 0.814½. All the ore has been milled at the Fairbanks custom mills, but the erection of a mill near the mine is contemplated.

PEARL CREEK VALLEY.

In the vicinity of the large mass of pegmatitic granite in the central part of the Pearl Creek valley many claims have been located by Michael Stepovitch and others, but the region has not been visited recently by members of the Survey, and no information concerning the results of the prospecting is available.

On the Smallwood-Pearl Creek divide Murphy and Perrault are reported to have been prospecting a vein on the American claim. A 50-foot shaft, the upper 8 feet of which was in talus, was sunk on this claim, and a vein from 18 inches to 4 feet in width, averaging 2 feet, is said to have been found. Several tons of ore were hauled to Fairbanks, and it is said yielded about $24 a ton in gold. On the adjoining claim to the south, the American Eagle claim, owned by the same men, is another vein, which the owners believe averages about 18 inches in width, and has a gold tenor of about $25 a ton. This vein has been opened up by a shaft 38 feet deep. According to report a dike cuts the lead, but its character was not learned, though the dike rock is said to have a gold content worth $15 a ton. Twenty tons of ore had been mined and was on the dump awaiting shipment in 1912.

TRIBUTARIES OF CHATANIKA RIVER.

WOLF CREEK VALLEY.

PENNSYLVANIA MINE AND VICINITY.

North of the War Eagle–Black Warrior group of claims, on the Wolf Creek side of the divide, are several other claims, on one of which, the Pennsylvania, at an elevation of 2,100 feet, the most development work has been done. The strike of the main vein on this property is N. 76° W. and the dip is 56° S. Gouge 3 to 4

inches wide occurs on the hanging wall, and the striæ on the slickensided surface dip at low angles on the plane of the hanging wall to the east. The ore is essentially similar to that at the other properties described. In some specimens taken near the surface the gold occurs in cracks between fragments of fractured quartz in a yellowish decomposition product formed by the breaking down of an antimony mineral. In such occurrences the gold probably has been deposited later than the quartz and the vein secondarily enriched. This enriched zone, however, is reported not to extend more than a few feet below the surface. The width of the vein varies somewhat, but averages about a foot.

Underground developments at the Pennsylvania consist of a 92-foot shaft, from the 50-foot level of which drifts have been run east and west for 20 to 30 feet. In the western drift several upraises have been started, and one of these, near the end of the drift, connects with the surface, though, owing to surface caving, it does not afford a traversable passage. Little work was in progress at the time of the writer's visit, as the owners were awaiting the completion of the mill.

Several mill tests of selected ore from this mine, made at Fairbanks, yielded, it is said, very high returns. The owners, however, estimate that the average tenor of the ore is about $40. The ore will be milled in a Little Giant mill, which was being built on the south side of Fairbanks Creek, on the creek claim known as No. 17 above. (See fig. 1, p. 143.) A well-constructed road about half a mile long connects the mine and the mill, affording a down-hill haul for loaded teams. The ore will be dumped from the wagons into a bin at the mill, from which it passes over a grizzly and is fed by an automatic distributing device to the muller. The crushed material flows over plates below the mortar and is then carried through a launder to a Monarch table. The estimated capacity of the mill, as now constructed, is 8 to 20 tons of ore a day, but the building was planned so that, when necessary, two additional mullers could be installed without affecting the present equipment. The problem of obtaining sufficient water for the mill is believed to have been solved by damming Fairbanks Creek so as to form a small pond and by using seepage water. As the mill stands at an elevation of about 1,850 feet, the amount of water available is small and some doubt is felt as to its sufficiency during the winter. No special precautions have been taken to overcome the low winter temperature, with the exception of heating the mill by placing the boiler inside the mill building. The owners expect that this mode of construction will allow the mill to be run throughout the year.

Near the Pennsylvania claim, on the Wolf-Fairbanks Creek divide, are two other claims on which some work has been done. At the

Dorothy claim, west of the Pennsylvania, a 95-foot shaft had been sunk on quartz stringers that appeared promising, but work had stopped and the shaft had caved and become inaccessible. Between the Dorothy and Pennsylvania is an abandoned tunnel, in which a quartz vein dipping steeply toward the south was found.

Prindle[1] notes:

> Near the head of Wolf Creek, on the Willie claim [see fig. 2], 4 to 5 feet of ferruginous quartz and mineralized schist have been exposed, from which gold can be panned. The strike is N. 50° E. and the dip 80° SE. It is reported that the deposit has been traced by float along this strike for about 1,000 feet.

HOMESTAKE MINE.

At the head of Wolf Creek, immediately south of the Nipsic claim (see fig. 2), the Homestake Mining Co. has been prospecting since 1908. In September, 1912, three men were at work on the property, which was being explored by means of a tunnel which at that time was over 650 feet long. At least five veins, which trend normal to the tunnel and which the tunnel is expected to intersect in depth, are known on the surface. These veins, like those on the Fairbanks-Wolf Creek divide, have a general east-west trend and dip southward at angles of 45° or more. Near the mouth of the tunnel is a small quartz stringer, which appears to dip steeply north, but this dip may be due to surface creep and may not be persistent in depth. A rich vein, on which 75 feet of drift to the east and 50 feet of drift to the west were driven, was found in the tunnel at a distance about 320 feet from its mouth. This vein is from 3 inches to a foot wide and carries much gold, 1,300 pounds of selected ore yielding, as reported, $308 in free gold. In addition the concentrates are said to have contained considerable gold and silver. Their reported high content of silver is surprising, as no distinct silver mineral was recognized in the specimens collected by the writer. Sulphides of antimony, copper, and iron form a small amount of the vein matter, but galena was practically absent and no silver sulphide was detected. The quartz is rather crystalline, though shattered here and there with open spaces into which well-terminated quartz crystals extend.

Some water has been struck in driving the tunnel, but it seems to occur mainly along fracture zones. Except for the fact that the ground has not stood well near these fissures and the personal discomfort of working in the wet places, the water has caused little or no trouble, as it is carried away by the grade of the tunnel. When mining deeper than the tunnel level is attempted pumping may be necessary. By the time the main lead is reached, and drifts

[1] Prindle, L. M., Auriferous quartz veins in the Fairbanks district: U. S. Geol. Survey Bull. 442, p. 227, 1910.

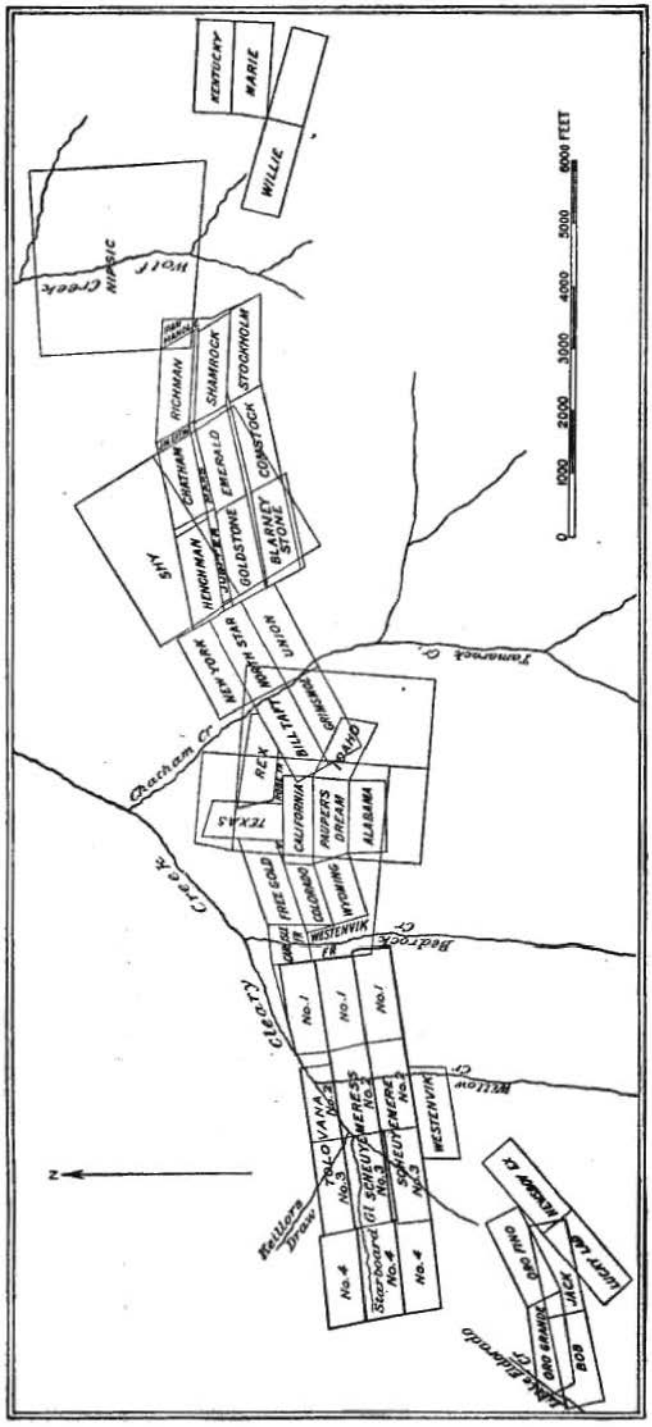


FIGURE 2.—Map showing location of lode claims in upper part of Cleary Creek valley, from map by L. S. Robe, 1909.

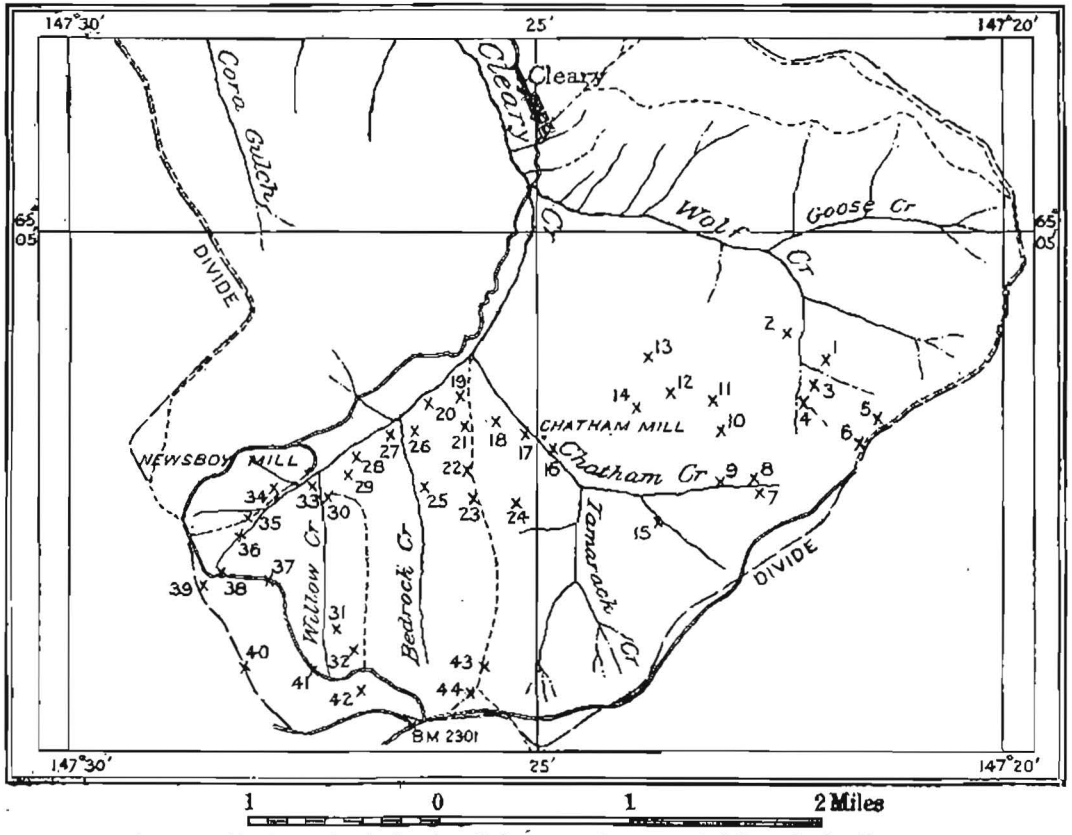
and stopes are turned off on the vein, sufficient information should be obtained to enable the owners to calculate closely the quantity of water to be handled, the cost of mining, and the tenor of the ore.

REXALL MINE.

A few hundred feet north of the Homestake Mining Co.'s tunnel is the Rexall claim (fig. 3), which was being actively worked by a crew of 5 to 10 men during 1912. This claim was staked in the summer of 1910 and more or less continuous work has been done on it ever since. Mining started on a large quartz vein, from 3 to 5 feet wide, trending N. 25° E. and dipping about 25° W. The vein material consisted almost entirely of quartz, and its gold content is reported to be rather low. About 140 feet south of the mouth of the adit a small vein, trending nearly east and west and dipping 60° N., was struck and, being much the richer, was followed, work on the larger vein being temporarily abandoned. A winze was sunk to water level on the smaller vein.

Mining had so obscured the relations of the two veins that the contact could not be fully seen. The superintendent stated that the small vein was simply an offshoot from the large vein, an interpretation that seems questionable, for he also stated that the small vein offset against the large vein and that the large vein carried considerably higher values between the junctions of the small veins. The condition is diagrammatically shown in figure 4, in which A and A′ are the offset small vein, and B and B′ the large vein, and the stippled area the richest portion of the veins. Such a condition suggests that AA′ had been faulted along a plane in general parallel to BB′ and that subsequent mineralization, by which the large vein BB′ was formed, took place along the fault. According to this interpretation the rich part of the vein between A and A′ may mark the dragged material formed by movement of the small vein on the old fault plane. A further bit of evidence suggesting that the smaller vein is older than the larger is the fact that the former is cut by faults of small displacement roughly parallel to the hypothetical fault, whereas the big vein, so far as traced, is not faulted.

The small vein is from 1 foot to 18 inches in width and has been opened underground by about 340 feet of drift. Several upraises have been made and the ground has been blocked out so that stoping can be begun when desired. The back of ore above the adit level in the present workings is estimated to be about 140 feet. Midway in the drift on the small vein a winze has been sunk to water level. At this place the vein is about 18 inches wide, and the hanging wall, which is much slickensided, carries 1 to 2 inches of gouge.



1. Banner.
2. Solomon.
3. Rexall.
4. Homestake.
5. Pennsylvania.
6. Dorothy.
7–9. Chatham Mining Co.
10. Harris & Brown.
11. Quemboe Bros.
12. Furstenseau.
13. Quemboe Bros.
14. Jupiter Mars.
15. Roughneck.
16. Pioneer.
17. Rex.
18. B.-P.
19. Cunningham.
20. Lyons.
21. California.
22. Pauper's Dream.
23. Alabama.
24. Bobbie.
25. Wyoming.
26. Rhoads-Hall.
27. Stepovitch.
28. Crosscut.
29. Tolovana Stibnite.
30. Tolovana.
31. Overgaard.
32. Emma.
33. Stibnite.
34. Scheuyemere.
35. Eldorado.
36. Steil.
37. ?
38. Newsboy Extension.
39. Newsboy.
40. ?
41. Cornell.
42. Cheyenne.
43. 44. Jackson.

FIGURE 3.—Sketch map showing location of lode prospects in upper part of Cleary Creek valley.

In addition to these two veins, small stringers of vein quartz that when panned yielded gold were discovered while excavations were being made for a mill site and a blacksmith's shop.

It is reported that 25 tons of ore from the small vein, milled at Fairbanks, yielded an average gold content of $112 a ton. It is also said that 10 tons of this ore yielded an average of $166 a ton, and that a 3-ton sample from the large vein gave a return of $37 in gold to the ton. All of these figures represent the values of the content of free gold, for the concentrates were not saved. A determination of the fineness of the gold from the Rexall, furnished by Frank W. Hawkins, of the Washington-Alaska Bank, gave 0.780½ and 0.785½, but the gold had not been thoroughly cleaned, so the true fineness is probably higher.

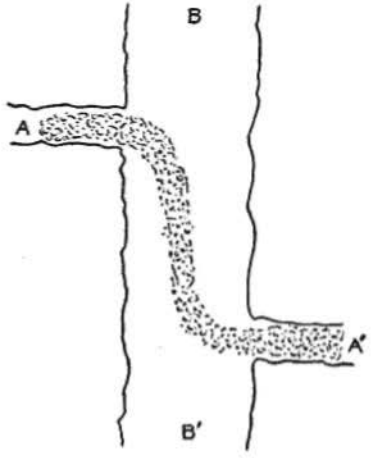


FIGURE 4.—Diagrammatic section of vein at Rexall mine, Wolf Creek.

At the time of the writer's visit (September, 1912) the operators at the Rexall were preparing to build a mill. The site had already been graded, the lumber was beginning to arrive on the ground, and the machinery was in Chena, so it was expected that the plant would be in operation before the close of the year. The mill is a 2-stamp Joshua Hendy mill and will be operated by a gasoline engine. Water for this mill has been procured by sinking a 35-foot shaft within the space to be occupied by the mill. This water supply is said to be more than sufficient during the summer, but it may not be adequate after the surface water is frozen.

MISCELLANEOUS PROPERTIES.

Above the Rexall cabin, at an elevation of 1,450 feet, a shaft has been sunk on the Banner claim. Work at this place has been abandoned for some time and the shaft had caved and partly filled, but ore carrying free gold is reported to have been found.

On the western slope of Wolf Creek valley, northwest of the Banner claim, prospecting has disclosed a 3 to 4 inch vein of quartz carrying a large amount of stibnite. The general trend of this vein is said to be northeasterly, but the pit had caved, and therefore the ledge was not examined by the writer.

In the small draw at the head of Wolf Creek, above the Homestake Mining Co.'s tunnel, are several shallow open cuts. On the dumps is a considerable amount of quartz, but all the work done

had been shallow prospecting, no underground development of the property having been attempted. No statements as to the results of this work were obtained, as the operator was absent at the time of the writer's visit.

On the Wolf Creek side of the Chatham-Wolf Creek divide, at an elevation of about 2,125 feet, the Quemboe brothers have discovered a vein trending N. 70° W. and dipping south. Development work at this place consists of a 60-foot shaft with a short drift to the east and another to the west. The dip of the vein and of the incline that follows it is steep near the surface, but flattens lower down. The ore shows some stringer banding and is much broken up. In parts of the vein the broken quartz fragments seem to have been cemented together by a subsequent infiltration of sulphides, the most abundant of which are stibnite, pyrite, and arsenopyrite. The rock is a rather soft schist and the vein appears to have been subjected to faulting by which its contact with the country rock on the hanging wall is marked by a plane of movement. Samples taken by the owners across the entire face of the vein are reported to have assayed $22.50 and $32 in gold a ton.

A peculiar fact reported in connection with the sinking of the shaft on this claim was that in its lower part considerable trouble with water was experienced and the shaft was temporarily abandoned. Some time later the water disappeared and the mine is now dry except for a little surface-water seepage down the shaft. The walls are a good deal cracked, owing to settling, and this cracking may account for the sudden disappearance of the water.

CHATHAM CREEK VALLEY.

CHATHAM MINE.

The Chatham Mining Co. is developing a lead on the eastern slopes of the valley, at the extreme head of Chatham Creek, at an elevation of 1,825 feet. The vein was disclosed at the surface in 10 shallow pits, which are so spaced that the ore is traced for more than 500 feet. In order to avoid difficulty with water, a crosscut tunnel 200 feet long was driven to the vein and drifts were turned off both to the east and to the west. The trend of the vein is N. 60° W., and its dip is from 65° to 80° SW. The estimated difference in elevation between the tunnel level and the outcrop of the vein is 180 feet. The vein ranges in width from 6 to 18 inches and has physical aspects similar to the quartz veins of low sulphide content previously described. The hanging wall shows pronounced slickensiding, the striæ being practically horizontal on its steeply inclined surface. In addition to this strike fault, dip faults are by no means uncommon. The greatest displacement of the vein so far

noted is 14 feet. Apparently the throw of all the faults is toward the southwest.

At the mine several hundred feet of drift has been driven along the vein, and slopes have been started, so that the mine has reached a producing stage. The ore is broken down on canvas and stored in mill holes undergound. It is then trammed to the surface and dumped into an ore bin, from which it is drawn as needed. About 10 men were employed undergound in 1912 and each is estimated to be mining about a ton of ore a day. Precise figures as to the tenor of the ore are not available, but the average value of the free gold content is reported to be between $25 and $40 a ton.

Across the small stream at the head of Chatham Creek near an old cabin is an adit owned by the Chatham Mining Co. This adit is said to be about 60 feet long, but it has been abandoned and is now so caved as to be inaccessible. Little mineralization is said to have been found in the adit, and if a vein was discovered it must be south of the one which is being mined.

The ore of the Chatham Mining Co. is treated at the company's mill on the lower part of Chatham Creek about a mile from the mine and 700 feet lower. The mill consists of two batteries, each of two 1,000-pound stamps of the Joshua Hendy pattern, dropping from 100 to 105 times a minute. The ore is crushed to pass through 40-mesh screens and the pulp flows over amalgamated plates. The tailings from the plates are not saved, so that there is probably a considerable loss. Water for the mill is obtained from a small ditch that was formerly used by placer miners near the junction of Cleary and Chatham creeks. At the time the mill was visited an abundance of water was available, but whether this source will be ample throughout the year is questionable. The difficulty of milling with water in cold weather is shown by the fact that even as early as September 13 the mill was closed down for a while at night on account of ice. The mine and the mill are connected by a good wagon road, a little more than a mile in length, over which the ore is hauled by horses.

PIONEER MINE.

Near the claims now held by the Pioneer Mining Co. on Chatham Creek, less than a mile above the junction of Chatham and Cleary creeks, the first quartz claim in the Fairbanks region was located on August 28, 1903, and recorded on November 24 of the same year by John C. Rose as the Blue Bell lode. Not much work was done on the ground until 1908–1909. Prindle,[1] who visited the property in 1909, made the following report concerning it:

> The Pioneer Quartz Mining Co. has done considerable work at this locality on a claim known as the North Star. A shaft was sunk near the creek to a depth of 24

[1] Prindle, L. M., Auriferous quartz veins in the Fairbanks district: U. S. Geol. Survey Bull. 442, p. 227, 1910.

feet, when water was encountered. A second shaft was sunk about 100 feet farther up the east slope of the valley to a depth of about 85 feet on a vein about 3 feet thick, striking northeast and southwest. This vein was found to intersect the smaller vein at nearly right angles. At the intersection the smaller vein, it is reported, follows the main vein for a short distance and then penetrates the country rock. The smaller vein is said to range from 4 inches to 2 feet 6 inches in thickness. Both veins carry free gold, but in the smaller vein there is considerable stibnite and arsenopyrite, with some sphalerite and iron pyrite. The distribution of the sulphides is irregular, but in the portion of the vein where they occur they are for the most part rather evenly distributed through the quartz. They show a slight tendency in some places, however, to form small seams in the quartz.

At the time of the writer's visit in 1912 no mining was in progress, as the men were engaged in building a mill, but the new shaft, which has been sunk 92 feet, starting about 20 feet above the level of the creek, was visited. Only a little water had been struck in the drifts turned off from the shaft, but the owners expect a stronger flow at a little greater depth. Drifts have been turned off both to the east and to the west of the shaft, the eastern one being much longer than the western; and stopes have been started, so that some ore is blocked out ready for mining as soon as the mill is completed. At the end of the eastern drift the vein is cut off by a fault, but the dislocation is slight, for the continuation of the lead has been picked up in surface pits beyond the fault with little offset.

A sample of the ore from the Pioneer Discovery claim was assayed by O. J. Tuschia, of the Monterey Mexico smelter, with the following results, the gold and silver content being omitted:

Assay of ore from Pioneer Discovery claim.

Copper (Cu)	None.
Lead (Pb)	None.
Silica (SiO_2)	95.1
Iron (Fe)	2.5
Lime (CaO)	.9
Zinc (Zn)	None.
Sulphur (S)	.3
	98.8

This analysis shows the high silica content and the small amount of metals other than iron. The sulphur content is so low that only a small amount is available to combine with the iron to form pyrite. Unless the low figure for sulphur is due to an error in analysis, it is probably to be accounted for by the oxidation of sulphides that originally may have been present.

Several shipments of ore have been made from this property for mill tests at Fairbanks, and returns of $30 to $90 a ton in gold are reported. From these tests the owners have felt justified in putting in a battery of five 1,000-pound stamps. The latter part of the summer of 1912 was spent in building the mill, which will probably be in

operation before the close of the year. Considerable difficulty in securing a suitable site for the mortar block was experienced, as at two places where excavations were started ground ice was found. Even at the place finally selected the foundation is none too good and a bed block 32 feet long containing more than 5,200 board feet of lumber was constructed to give sufficient support for the battery. Water for the mill will be obtained by pumping from the now abandoned shaft, over 100 feet deep, on the west side of Chatham Creek. No accurate estimates of the amount of water that can be obtained from this source have been made, but the fact that the earlier lode miners were unable to control the water is considered sufficient evidence that the supply will be adequate.

PROSPECTS ON EASTERN SLOPE.

On the hillside above the Pioneer Co.'s shaft and between that property and the Chatham Mining Co.'s ground a number of veins have been located and some work has been done, but none had reached a producing stage in 1912. The Jupiter-Mars Consolidated Mining Co. has seven or eight claims on the eastern hillside, and on the Gladstone claim, at an elevation of about 1,700 feet, it has driven two tunnels a short distance on a flat-lying lead. The vein trends about east and west and dips southward into the hill at a variable though low angle. Several faults intersect the vein, which does not appear at all regular. The miners believe that the part now being mined may be a large piece of slide and that farther up the hill the vein may be more regular. Not enough development work had yet been done to show the true condition, but in the northernmost tunnel the vein is abruptly cut off to the left by well-rounded gravels and wash. The gravel is similar to an ordinary river deposit and consists of pebbles of schist and quartz in a fine-grained, rather dirty matrix. The gravels are frozen, and therefore hold together well in the mine, but are not well consolidated. East of this place a 66-foot shaft has been sunk, and several other pits have been put down to prospect the ground. Shipments of a ton or so of ore from several of the veins have been tested at Fairbanks, and the average gold tenor of the ore is said to be about $30 a ton. Sulphides form but a small part of the vein material.

Farther north, on the ridge between Wolf and Chatham creeks, at an elevation of 1,850 feet, is a short tunnel of the Sky High claim. The lead at this place is a very much decomposed brown, iron-stained material, 3 to 6 inches wide, dissimilar from any of the other leads in the vicinity. Not enough development has been done to show the extent and character of the vein, but it appears to lie very nearly horizontal and suggests an iron capping rather than

a vein. It is reported that the limonitic material affords gold on panning but that the amount is usually small. On the next adjacent claim a lead said to be 14 feet wide is rumored to have been opened by a short tunnel, but its gold content is small and little work has been done on it.

Southeast of the Sky High claim, at an elevation of 1,875 feet, in a now abandoned shaft, 60 feet deep, an east-west vein was discovered. No production, however, has been made from this place.

On the summit of the hill, between the two northernmost pinnacles of schist, at an elevation of about 2,050 feet, Harris & Brown have sunk a shaft 50 feet deep on a vein that trends N. 70° E. and dips at a high angle. The ore seems similar to that from the veins having a low sulphide content. One exceptional phase, however, was noted, in which the quartz was strongly brecciated and the fragments were cemented together by a matrix of crushed quartz. The cementation is so strong that the rock breaks across the large quartz fragments and the matrix appears like a quartzite. A somewhat similar rock, in which the matrix is formed of stibnite instead of quartz, was also seen. This rock shows that the sulphides were formed at a rather late stage in the vein filling. This phase is said to occur rather irregularly and forms but a small amount of the material cut by the shaft.

PROSPECTS ON WESTERN SLOPE.

Less than half a mile above the junction of Cleary and Chatham creeks, on the west side of the latter stream, is the B. P. claim, which has been more or less continuously prospected since 1908, though during 1912 the property was idle. Prindle, who visited the prospect in 1909, describes it as follows:[1]

> At a level of 150 feet above the creek a tunnel was driven southwest for about 90 feet. At 50 feet from the mouth of the tunnel a shear zone was encountered, about 6 feet thick, striking northwest nearly at right angles with the strike of the schists. The operators drifted northwest and then sunk on the shear zone, which was found to dip from 45° to 70° SW. to a depth of 150 feet, where the thickness was about the same as in the tunnel. Later a raise was put in above the winze, connecting it with the surface. The second level is about 100 feet below the first and extends along the vein for about 40 feet on each side of the shaft.
>
> The mica schist of the shear zone was found to be impregnated with sulphides, chiefly iron pyrites and arsenopyrite, with some galena, sphalerite, and stibnite. These sulphides also occur in the numerous quartz veins that penetrate the shear zone. Free gold is found in the upper, more oxidized portions of the mineralized zone, but it is reported that in the less decomposed lower portions of the lode the values are in the sulphides. A noteworthy feature is the occurrence of tourmaline needles in the mica schist close to the contact of schist and quartz veins and in close association with iron pyrites and arsenopyrite.

[1] Prindle, L. M., Auriferous quartz veins in the Fairbanks district: U. S. Geol. Survey Bull. 442, p. 226, 1910.

Difficulty with water caused the abandonment of mining for a while, but later an attempt was made to determine the quality of ore below the water level by sinking an inclined shaft. The venture was soon abandoned, however, and failed in its object. It is to be regretted that this particular lead was selected, for it does not appear to be typical of the majority of auriferous quartz veins. It is, instead, as Prindle describes it, a shear zone with an abnormally large amount of sulphides, even near the surface, and the free gold it carries is confined mainly to its weathered superficial portion, where the sulphides have been broken down and decomposed. As might have been expected, therefore, a short distance below the surface the ore became base and its value decreased.

Near the creek, between the B. P. and Pioneer claims, is the Rex Mining Co.'s claim. Owing to legal difficulties, little work has been done at this place. According to Brooks,[1] some work was done on the Rex during 1911, but when visited in 1912 no work was in progress and the place was deserted.

On the Bobbie claim, west of the junction of Tamarack and Chatham creeks, at an elevation of 1,650 feet, several shallow pits have been sunk and a tunnel has been driven on a lode striking nearly north and south and dipping westward into the hill. No work has been done at this place recently, and most of the pits are too much caved to allow examination. Specimens of the ore, however, indicate that the vein belongs to the group having a high sulphide content. The ore consists mostly of stibnite and galena with other sulphides in smaller quantities. In the midst of the sulphides are numerous well-formed quartz crystals with uncorroded surfaces and random orientation. Several of the quartz crystals are more than an inch in length and a quarter of an inch in diameter.

In the short incline from the open cut on this claim is a narrow stringer of nearly pure galena. This vein shows well-marked banded structure near the walls, the center of the vein being completely filled with large crystals of galena. The galena is reported to carry considerable silver, but the charges for treating this kind of ore are so high that the property can not be commercially developed in the near future, even if a much larger body of ore than has yet been found should be discovered.

BEDROCK CREEK VALLEY.

RHOADS-HALL MINE.

East of the lower part of Bedrock Creek (see fig. 3, p. 156), on the Free Gold claim, is the Rhoads-Hall mine, which was located in 1908 and is the largest mine in the region. It has been operated

[1] Brooks, A. H., The mining industry in 1911: U. S. Geol. Survey Bull. 520, p. 31, 1912.

more or less continuously since its location and was practically the only producing mine up to 1911. The main vein is from 1 to 3 feet wide. The ore shows many different phases, but consists essentially of quartz with little or no sulphides. In places it is so much crushed that it is almost like sand. The vein includes schist horses a few feet long. It cuts the structure of the schists that form the country rock at the mine at rather high angles. The dip is fairly constant, the highest dip noted being 63° S. and the lowest dip about 55° S. Owing to faulting the trend of the vein is not constant, but averages about N. 75° W. Parallel to the main vein at a distance of about 25 feet in both the hanging and foot walls, are narrower quartz stringers composed of ore of the same kind, though of somewhat lower tenor.

The underground development of the property consists of a main adit over 975 feet long, started about 50 feet above the creek; an intermediate adit about 140 feet farther up; and an upper adit 50 feet still higher. The walls stand well, so that little timbering is necessary. This is fortunate, for a set of round-pole timbers costs at the mine about $3 and square timbers about $6. Little machinery has been used, as all drilling and tramming are done by hand and pumping is not necessary, for the adits drain the workings. A winze sunk to a depth of 20 feet at a point about 800 feet from the mouth of the adit encountered but little water and is to be carried lower. An electric pump is on the ground ready to be installed if water in troublesome amounts is found.

The dislocation of the vein by faulting makes the deposit difficult to open up and materially increases the cost of mining. A short distance from the mouth of the main adit, in an area at least 200 feet on a side, the rock is so thoroughly broken and sheared that the vein in it is practically unrecognizable. Slickensides are so numerous, diverge so greatly, and have formed at so many different times that they are of little service in determining the direction of movement at any particular place. In fact, many specimens of rock less than 3 inches cube show slickensides in three or four directions. Outside this highly shattered region the faults cutting the vein are of relatively small displacement. There are two distinct sets of these smaller faults. One set trends transverse to the vein and has a high inclination; the other trends nearly parallel to the vein and is practically flat. The usual effect of these faults is to throw the vein toward the footwall; that is, toward the north.

Much of the gold is irregularly distributed through the vein material in visible particles uncombined with other elements. In some places the vein is richest immediately adjacent to its walls; in other places it is richest in its center. The ore is in large part free from sulphides, but here and there includes stibnite, some galena, and

arsenopyrite, as well as lesser amounts of pyrite, copper pyrites, and sphalerite. These sulphide-rich portions of the vein also contain gold, and Prindle [1] states that the gold sulphides and some quartz apparently have been introduced together at a period subsequent to that at which much of the quartz was formed. It therefore appears that the gold was introduced at two distinct times—first with the quartz and second with the sulphides. It is, however, by no means certain that the two events were separated by a long period.

According to the manager at the Rhoads-Hall mine, no material difference has yet been noticed in the tenor of the ore or in the amount of sulphides. In the highest level, near the surface, according to report, some sulphide enrichment was found, but none of the specimens seen indicated this process, although it may have taken place in the surficial portions of the deposit. Some oxidation of the sulphides has occurred to as great depths as have been reached by mining, but its amount is not great, as most of these minerals are hard and have the appearance and composition of unweathered material.

Three assays reported by F. W. Hawkins show that the gold from this property is 0.793, 0.820, and 0.830 fine and that the silver is 0.180, 0.164, and 0.164 fine. Silver is seldom actually determined by the Fairbanks assayers, and nine assays give only the fineness of the gold, namely: 0.802½, 0.810, 0.810½, 0.820, 0.822, 0.824½, 0.826, 0.827, 0.830. The average of these 12 determinations is nearly 0.818, which is equivalent to a gold value of about $16.89 an ounce. The fineness of the silver in the bullion, according to the usual method of estimating it as the difference between 0.990 and the fineness of the gold, is about 0.171½, which, with silver at 54 cents an ounce, would indicate a value of 9 cents.

No accurate figures as to the tenor of the ore are available. It is reported that 147 tons treated at the Chena mill in 1911 yielded $17,645, or an average of $120 a ton.[2] The conditions under which this ore was selected are not known, but the shipment was probably picked material.

For several years small shipments of ore were made from the Rhoads-Hall mine to the testing mills at Chena and Fairbanks, and it is reported that this mine furnished the first ore milled in the Tanana Valley. The development of the mine and the high charges for transporting the ore led the owners to put up a stamp mill on the property in 1911. After running about a month in 1911 the mill was closed on account of shortage of water until the spring of 1912. Since that

[1] Prindle, L. M., op. cit.

[2] These figures, together with others given on later pages, were furnished to the Geological Survey, but as they have subsequently been published in the Fairbanks newspapers (Alaska Citizen, June 3, 1912) no confidence is violated by using them in this report.

time it has been in more or less continuous operation and the owners hope that they will not be forced to close it down during winter. The mill has a single battery of five 1,000-pound stamps of the Joshua Hendy pattern, operated at present by steam from a wood-burning boiler. The estimated capacity of the mill is about 17 tons of ore (about 3½ tons per stamp) in a day of 24 hours. Water for the mill is supplied during the summer by a short ditch and flume, but will be pumped during the winter from a well recently sunk.

The milling practice at this mine is relatively simple. The crushed ore flows through a 40-mesh screen and over the amalgamated plates, from which the tailings run over a canvas-covered table, and the material that is discharged from it is distributed by launders to a settling pond near the creek. Most of the free gold is caught in the batteries or on the plates. Some of the gold contained in the sulphides is recovered on the canvas-covered table, but a large amount of it is carried to the settling pond. The owners intend to install a vanner soon and believe it will effect a material saving. A table is necessary not only to recover the gold in the sulphides, but also to recover some of the free gold which, in an ore containing much stibnite or arsenopyrite, is likely to be carried off, owing to the sliming of the plates. When much of the stibnite ore is being milled it is necessary to dress the plates about once in three hours, or large losses of native gold result.

The concentrates are scraped off the canvas table from time to time and saved until enough have accumulated to pay for shipping. As they come from the table they are nearly black, but in about a week they oxidize to an iron-rust brown.

TANANA QUARTZ & HYDRAULIC MINING CO.'S CLAIMS.

A short distance south of the Rhoads-Hall mine are claims of the Tanana Quartz & Hydraulic Mining Co. and of men interested in that company. On this group of claims there are three leads, two trending about N. 75° W., and one trending nearly north and south.

The northernmost of the parallel veins, which has been prospected on the California and V claims, may be the continuation of the main lead at the Rhoads-Hall mine, with which it is nearly in line. The westernmost shaft on the vein starts from a point west of Bedrock Creek at an elevation of about 1,400 feet, with an inclination of 60° S., which about 20 feet below the surface decreases to 40° and continues at this angle for about 40 feet. A strong vein, from 1 to 3 feet wide, can be traced to a point near the bottom of the incline, where it is cut off by a fault. The ore appears similar to that of the richer veins of the region but is reported to be of low tenor, though little of it has been adequately tested.

Another shaft has been sunk somewhat farther east on the supposed continuation of this vein near the road on the Bedrock-Chatham divide, at an elevation of about 1,400 feet. Mining was not in progress at this place in 1912, and the underground workings were so full of water that they could not be examined. The material on the dump and descriptions given by those familiar with the place indicate that the vein is of the non sulphide-bearing type, and some tests showed it to carry gold. Fragments of a light-colored feldspar and quartz rock found on the dump and said to come from points close to the vein apparently belong to the granite family.

A number of shallow pits sunk on the same or parallel leads east of the old road have disclosed auriferous quartz. More than a thousand feet of prospecting with a Keystone drill has also been done in this region, but no rich veins have been discovered.

The southern east-west vein is on the Wyoming and Alabama claims, and has been most extensively opened up on the Wyoming claim by an adit 165 feet long, the mouth of which is on the eastern slope of the valley of Bedrock Creek, at an elevation of about 1,325 feet. A 50-foot winze, starting with an inclination of 60°, but flattening to 49° near its bottom, has been sunk on the vein near the center of the adit. These openings have disclosed a vein 1 to 2 feet wide, the crushed rock from which yields considerable free gold on panning. Some ore has been shipped to the custom mills at Fairbanks and is said to have yielded high returns in gold. The vein cuts the country rock at a steep angle and seems in part to occupy a fault fracture. The country rock in this part of the area is greenish and less laminated than that to the north, and in its physical features resembles a sheared and metamorphosed greenstone. The vein contains, just beyond the winze, several long, chimney-like vugs partly filled with crystals of quartz and calcite, the calcite being younger than and coating the quartz. The occurrence of calcite in the veins is rather unusual, and the vugs probably represent openings formed by late fracturing of the auriferous veins and the subsequent deposition of quartz and later of calcite. So far as could be learned these vugs carry no gold and do not affect the tenor of the vein. A peculiar feature noted in this mine was that though the surface of the main adit was heavily covered with ice crystals, some of them as much as 3 inches long, none occurred in the winze.

On the hillside above the adit, prospect pits have been sunk at intervals to a point on the crest of the divide at 1,825 feet, and in them quartz vein material, some of which yields free gold, was discovered. According to Antone Goessmann, one of the prospectors most familiar with the property, a panful of surface material taken practically anywhere on the hillside yields particles of gold, many of good size and all sharp and angular, as though untransported.

The north-south vein is exposed at the surface on the lower part of the crest of the divide between Bedrock and Chatham creeks, on claims called the Paupers Dream and the Texas—the former south of the latter—and crosses the California claim, already noted, which lies between the two. (See fig. 2, p. 154.) The southernmost opening on this vein is near the old ridge road at an elevation of 1,625 feet. The vein dips west at a high angle and is from 2 to 4 feet wide. Unlike the parallel east-west veins, this one carries a large amount of sulphides, mainly arsenopyrite, but it also contains free gold. Much coarse angular gold is reported to have been found in the weathered material overlying the vein. This vein appears to pass a little east of the shaft near the road on the California claim, previously described, but the relation of the two sets of veins is not determinable from the present exposures.

MISCELLANEOUS PROPERTIES.

On the divide between Bedrock and Chatham creeks, at an elevation of about 1,300 feet, and nearly in line with the north-south vein on the Texas and Paupers Dream claims, a short tunnel has been driven into the hillside on a small vein carrying a large amount of arsenopyrite and some stibnite. From the tunnel a short winze has been sunk, but the property is now lying idle, and the workings are partly filled with water. The vein is well defined and has a smooth wall apparently due to faulting. Samples from this place are said to carry much gold, but no systematic sampling has been done, and no ore has been milled.

Near the rocky pinnacle at an elevation of 2,300 feet on the Bedrock-Chatham divide a small mass of quartz, galena, iron pyrite, arsenopyrite, and stibnite is interbedded in the schists. Nearly due south of this place, at an elevation of 2,400 feet, is a shallow shaft, now filled with water. On the dump is considerable galena. In a short tunnel driven into the hillside below the shaft similar ore has been found. It was reported that the deposit occurred in a blanket formation and that the vein in the tunnel and the one in the shaft were not the same, but were parallel. The exposures afforded no ground for a definite conclusion, but the apparent flatness of the deposit seems to be due to surface creep, and does not represent the true attitude of the vein. Further prospecting is much needed to determine the extent and size of the ore body. The only other lode carrying large amounts of galena, the Bobbie (see p. 163), which strikes nearly north and south and dips westward, lies less than a mile N. 10° E. of this shaft. The similarity of the ores at the two places and their nearness suggests that the two lodes are probably genetically related. The fact that this galena occurs only about one-eighth mile from a small area of intrusive rock that is exposed near the

2,301-foot bench mark, at the crossroads, is also significant. The galena from this claim occurs both in large, well-crystallized cubes and in fine-grained masses, the latter usually lying close to the walls and the former being more remote. Strong evidences of faulting are recognizable throughout the vein material and country rock. The galena is reported to carry much more gold than silver, but the tenor of the vein has not been accurately determined.

On the ridge about a quarter of a mile west of the 2,301-foot bench mark, near the western end of the mapped area of igneous rock, several shallow pits have been sunk into the frost-riven talus in attempting to locate the lead that furnished much of the quartz lying on the surface. The direction and character of the lead can not be determined from the present exposures. Assays of samples from this lead are said to have shown a gold tenor of about $10 a ton.

WILLOW CREEK VALLEY.

TOLOVANA MINE.

At an elevation of 1,300 feet, or about 25 feet above Willow Creek, a little more than one-eighth mile upstream from its junction with Cleary Creek, is the Tolovana mine. The main development at this place consists of an adit that follows the vein for about 130 feet to a fault which throws the vein northward about 30 feet. Beyond this offset the adit continues eastward for about 200 feet. Short crosscuts have been turned off here and there on small stringers, and some ground has been stoped above the level.

About a hundred feet from the mouth of the adit an inclined winze has been sunk, from which a drift has been turned off 50 feet below the adit. The fault discovered in the adit was found also in this drift and offsets the vein to the north. An inclined winze near the east end of this lower level, said to have been sunk on the vein, was full of water in 1912 and could not be examined. In the western part of the lower drift some ore has been stoped and hoisted up the winze to the adit level and thence trammed to the mill. At the time of the writer's visit, however, a shaft with an inclination of 60° S. had been sunk near the mouth of the adit, had intersected the 50-foot level, and was being driven deeper. This shaft will be used for hoisting ore from the lower levels.

Water has caused some difficulty in the sinking of the shaft. According to the superintendent, it accumulates in the bottom of the shaft at the rate of about 2 feet per hour, making continuous pumping necessary. As the bottom of the shaft is now more than 40 feet below the level of the creek and as it is probable that the most pervious part of the ground has been passed through, no excessive increase in the amount of water is expected.

The vein at the Tolovana trends nearly east and west and dips about 60° S. It differs from the other veins so far described in that the quartz forms small stringers, 1 to 3 inches wide, separated by considerable thicknesses of schist. The quartz is commonly frozen to the wall rocks so firmly that blasting does not separate them. In many places the country rock close to the vein is heavily impregnated with sulphides, mainly of iron. These are especially abundant where the wall rock is somewhat calcareous. In the vein, however, iron pyrite is practically absent, the common metallic minerals being stibnite and gold. The stibnite generally occurs in more or less well formed crystals, many of which are small, isolated needles of nearly microscopic dimensions; no large masses have been found. In certain specimens stibnite lies along the granulation planes in the quartz, giving the rock a linear-parallel gneissic structure.

The gold is mainly native. Little or none is said to be contained in the stibnite, but some particles of gold are visibly in contact with the stibnite, and others bear all relations from close association to complete separation. In many specimens the gold occurs in crystalline aggregates in the midst of unfractured, somewhat glassy quartz and seems to have been introduced with the quartz and before the infiltration of the stibnite. It is reported, however, to be most abundant in ore containing some stibnite.

Determinations furnished by F. W. Hawkins show the gold to be 0.824, 0.821½, 0.819, 0.814, and 0.792 fine. The sample whose gold fineness is 0.792 contained 180 parts per thousand of silver.

The quartz is generally compact and rather milky. Here and there, however, small vugs occur in the vein, and these are usually coated with crystals of glassy quartz. Widespread shearing of the quartz has produced a structure resembling cleavage, causing glistening faces in parallel orientation to appear on fractured surfaces. A little feldspar is recognizable in some of the vein material; and Prindle[1] notes that a minute vein at this locality was found to be composed of quartz and fresh albite. In a few places a small amount of calcite is also associated with the quartz.

At two places on the Tolovana property veins carrying much stibnite have been found; one east of Willow Creek, at an elevation of about 1,325 feet; the other west of it, at about 1,300 feet. The eastern locality has been prospected by shallow pits, but the ledge has not been found in place. The stibnite occurs both in well-formed blades with characteristic pressure twinning and also in more or less massive form, intimately intermixed with other sulphides, notably those of iron. Red, yellow, and greenish-yellow oxidation products are common, but are more abundant on the well-bladed than on the

[1] Prindle, L. M., op. cit., p. 227.

massive ore. Below these pits a prospecting tunnel about 100 feet long has been run nearly due south, but has not yet reached the place where the stibnite vein is believed to occur. Possibly its course may be parallel rather than transverse to the vein, in which case it will yield no information concerning the vein. About 50 feet from the mouth of this tunnel a few small quartz stringers were found, but no well-defined lead was discovered. This method of prospecting appears to be much more expensive than surface trenching and sinking test pits on promising leads.

A shaft at the locality west of Willow Creek is now filled with water and can not be examined. It is reported to have been sunk 16 feet on a small stringer carrying large amounts of stibnite. Several shallower holes were also put down, but disclosed no material that warranted development at that time, and further prospecting at this place in the near future seems unlikely.

A Huntington mill was in operation at the Tolovana mine in 1911, but was found not to be adapted to the work and was closed down early in the summer of 1912 to permit the installation of two Nissen stamps of 1,300 pounds each. Operations were resumed in September. The old mill was closed down during the winter of 1911–12, but if possible the new one will be kept running throughout the year. Seepage water pumped from the new shaft was used during the summer, and it is hoped that water from a well just sunk will supply all needs during the winter. The rock is difficult to crush, the estimated capacity of the mill being less than 8 tons a day of 24 hours. The ore is trammed from the mine, dumped over a grizzly, the larger pieces being put through a small power crusher, and is delivered to a storage bin, from which it is automatically fed to the stamps. The pulp, passing through 40-mesh screens, flows over the amalgamated plates. The tailings are discharged at the lower end of the plates onto an endless conveyor with a slope opposite to that of the plates and with the belt moving in an opposite direction to the slope. By this arrangement the heavier minerals are concentrated and carried to the head of the belt, where they are dumped into a receptacle, from which they are taken when enough have accumulated to warrant metallurgical treatment.

MISCELLANEOUS PROPERTIES.

At the head of Willow Creek some prospecting has been done on ground leased from the Newsboy Mining Co. by Dr. I. Overgaard. On the Emma claim, at an elevation of about 2,025 feet east of the creek, a shaft 60 feet deep has been sunk on a promising stringer 6 inches wide, and short drifts have been turned off at the bottom. The country rock differs on the two sides of the lead; on one side it seems to be a metamorphic igneous rock of the greenstone group. The dip

of the vein at the surface is steep to the south, but in depth it decreases to about 45°. Particles of gold are recognizable in some of the ore that has been sacked for shipment. According to the operator, 10 tons of selected ore milled at Fairbanks yielded an average gold tenor of $38 a ton.

A short tunnel into the compact unmineralized rock has been started at an elevation of about 1,775 feet. No valuable minerals have been found in the tunnel, but a short distance below it a strong quartz lead is exposed. Unfortunately, however, assays of the quartz are said to show little gold.

An ingenious hand mill capable of treating about 100 pounds of ore in five or six hours has been built at this place. It consists of a heavy iron bar, expanded at the base, which is raised by means of a lever with the necessary tackle and is dropped into a mortar box which has a one-way discharge. The pulp flows over amalgamated plates, and the concentrates in the tailings are not saved. Water is derived from the near-by stream. The entire apparatus was manufactured on the ground, and though it can handle only a small amount of ore, it could be of service in testing vein material in places remote from capable assayers.

Near the road west of the Overgaard property, at an elevation of 2,075 feet, is the abandoned Cornell tunnel, which is reported to have been driven as a crosscut to prospect the region. Apparently no ore was discovered.

A shallow prospect pit has been sunk in an area showing some disseminated sulphide mineralization on the ridge between Willow Creek and the head of Cleary Creek, just above the road, at an elevation of 1,900 feet. This pit, which has been abandoned for several years, is near the western margin of a small area of intrusive rock, which has a mottled porphyritic appearance and which on weathered surfaces is heavily covered with limonite. Probably the sulphides noted in the schist were introduced through its agency. Apparently the deposit at this place has no economic value.

CLEARY CREEK VALLEY ABOVE WILLOW CREEK.

NEWSBOY MINE.

On the divide between Cleary and Last Chance creeks, at an elevation of about 1,875 feet, the inclined shaft of the Newsboy mine has been sunk nearly 350 feet and drifts turned off at the 60, 115, 215, and 315 foot levels. At the time of the writer's visit the mine had been closed down for some time, owing to alterations in the mill, and water that had collected in the bottom of the shaft made the lowest level inaccessible.

The Newsboy vein trends about N. 40° E. and dips about 73° NW. Its width ranges from less than 1 foot up to 9 feet, averaging between

2 and 3 feet. The ore is much sheared and consequently breaks down rather easily, leaving smooth walls; but the vein matter is tightly frozen to the country rock and therefore some ore is left in what are called the walls, or else some waste rock is mined with the vein material.

Large amounts of sulphides occur in the vein, but the ore differs from that seen at any of the mines so far described, though it is more closely akin to that of the Tolovana than to that of the more eastern veins. The sulphides are mainly pyrite and stibnite, though arsenopyrite, a little chalcopyrite, and sphalerite have been recognized. Quartz, although the most abundant mineral, forms a rather smaller proportion of the vein material than in most of the other mines. Most of the quartz simulates that in the quartzite rather than that in the normal veins and has a fine granular texture. Schist horses are fairly numerous in the vein and are not sharply separated from the vein material.

On the 215-foot level a drift has been run northeastward for about 200 feet, and midway in its length has been connected by an incline with the 115-foot level, thus blocking out a mass of ore for stoping. At the east end of this drift the vein is cut off by a transverse fault, and its eastward continuation has not yet been found. Most of the country rock is hard and very compact, suggesting affinity with the metamorphic greenstones, and throughout its extent is practically without any recognizable guide horizon. The fault plane is strongly slickensided; the direction of movement appears to have been sideways rather than vertical, but the rock does not preserve the scratches well enough to show toward which side the movement took place. Under these conditions the continuation of the vein can probably be found only by crosscutting beyond the fault.

Farther west on the same level a drift about 100 feet long, following the vein, cut another transverse fault similar to the eastern one, but dipping in the opposite direction.

On the 115-foot level a 40-foot drift has been turned off to the southwest and a 100-foot drift to the northeast. In the western drift the ore is said to be cut off by a fault, beyond which the vein has not been traced. In the eastern drift the vein is cut off by a transverse fault, which, if identical with that on the 215-foot level, may be expected to cut the vein on the 315-foot level about 300 feet from the shaft. It is doubtful, however, whether these two are the same fault, for if they are they should have displaced the vein above the 115-foot level, which apparently they have not done.

A raise has been driven from the 115-foot level to the 60-foot level. The 60-foot level runs northeastward for about 75 feet, and much of the ore above it has been stoped out. The ore has not been

traced southwestward from the shaft, and this suggests that it is cut off by the southwestern fault.

The average tenor of the ore is not known, for considerable parts of the several large shipments made were hand picked. Sixty-six tons of ore treated in 1911 at the Chena mill are reported to have given an average free gold content of $81.50, and 7½ tons treated at the Garden Island mill, at Fairbanks, are said to have yielded $104 in gold per ton. According to another report, the ore is said to run about $40 a ton in gold.[1] The causes for these differences are not fully known, but, so far as could be learned, the controlling factor is not depth below the surface.

For some time the ore from the Newsboy mine was shipped to the custom mills at Chena and Fairbanks, but late in the fall of 1911 a 5-stamp Hendy mill was built at the mine. Seepage water pumped from the mine was first used in the mill, but the supply was not entirely adequate, and in 1912 the mill was moved to a point on Cleary Creek near the mouth of Willow Creek, at an elevation of more than 600 feet below the mine. The work of removal had not been completed by the middle of September, but the mill was probably running again before the end of the year. The new site is over three-quarters of a mile from the mine, and it will be necessary to haul the ore by teams. Water will be supplied from a 6-inch drill hole 100 feet deep in amounts which the operators hope will be adequate throughout the year.

The mill is equipped with a battery of five 1,000-pound stamps, and a No. 2 Deister concentrator is used for saving the heavy minerals in the tailings. The mill superintendent estimates that 10 to 12 tons of ore can be milled a day, at a cost for both mining and milling of $7 a ton. If this estimate is correct, the cost will be much less than that at any of the other properties examined. Wood, costing about $15 a cord, is used for fuel.

NEWSBOY EXTENSION MINE.

About 500 feet northeast of the Newsboy is the so-called Newsboy Extension shaft. The faulting of the vein at the Newsboy makes it impossible to tell whether the same vein is really continued in the Newsboy Extension. Certainly the strike of the two veins is not the same, for that at the Newsboy strikes N. 40° E. and dips 73° NW., whereas that at the Newsboy Extension strikes N. 15° E. and dips 77° W.

The Newsboy Extension mine has not been worked for some time, and in 1912 the shaft was nearly full of water, which prevented examination of the underground workings. The operators report

[1] Eng. and Min. Jour., vol. 93, No. 26, p. 1291, June 29, 1912.

that the shaft is about 115 feet deep and that short drifts have been turned off both to the north and south at the 60-foot level. The country rock and ore, as seen on the dump and in the bins, is apparently much the same as that from the Newsboy, except that it contains even less quartz. No accurate determination of the gold tenor of the ore has been made, but it is said to be about $15 a ton.

Connected with the shaft house at the Newsboy Extension is a 5-stamp mill built by a Fairbanks company. The stamps weigh about 500 pounds, and it is reported that the mill can crush about 8 tons of ore a day. The machinery, however, is very light to treat rock so hard to crush as that from this mine, and its operation has been difficult. The mill stands so high on the ridge that little water is available, and the supply, which has been obtained by pumping from the shaft, has apparently not always been adequate. The mill has not been in operation recently.

MISCELLANEOUS PROPERTIES.

About a quarter of a mile above Willow Creek, at an elevation of 1,325 feet north of Cleary Creek, a short shaft and tunnel have been driven on the Scheuyemere claim. The country rock is of the usual schistose type, and the material on the dump shows many pieces of rather glassy quartz. As mining had ceased for so long a time that the pits had caved and as there were no outcrops, exposures of the vein were not seen, and not even its direction or extent could be determined. No ore was milled from this property.

On the ridge between the two small headwater branches of Cleary Creek, at an elevation of 1,375 feet, is a 30-foot shaft of the Eldorado Mining Co. No work has been done here for two years, and the shaft is filled to the surface with water. The ore on the dump does not appear to be very promising. It is mainly quartz, though some stibnite occurs in the seams. The trend of the lead, as indicated by the direction of the shaft, is about north and south. Limestone apparently forms part of the country rock, for it makes up a considerable proportion of the dump. Pieces of brownish-gray, rather crystalline limestone and of blue compact crystalline limestone were fairly numerous, and some fragments of schistose limestone, with considerable mica and chlorite on the cleavage planes, were also found. These limestones probably belong to the general group mapped by Prindle and Katz as occurring along the road northeast of the shaft and on top of the hill to the north. In none of the other prospects was any considerable amount of limestone noted.

South of the Eldorado shaft, at an elevation of 1,475 feet, is the Steil tunnel. The tunnel was closed and the vein could not be examined in place. The vein material on the dump, however, indicated

that it is more like that from the vein in the Tolovana mine than that from the more easterly veins. The quartz occurs in narrow veins that branch here and there through the country rock, which appears more compact and harder than the silvery schist and suggests relationships with the greenstones rather than with the sedimentary rocks. The veins are firmly frozen to the country rock and fracture with it. Some stibnite and less pyrite occur in the ore. A road has been built from the tunnel to the main road to the north, and small lots of ore will probably be hauled to one of the near-by mills for treatment. In 1912, however, the property had not reached the producing stage.

ELDORADO CREEK VALLEY.

Little lode prospecting has been done in the Eldorado Creek basin, but the general geologic conditions there appear to be similar to those in regions that contain auriferous veins. On the Rose claim, which lies about a quarter of a mile south of the Newsboy mine, an adit 180 feet long has been driven on a quartz vein about 1 foot wide. Two tons of the ore, milled at one of the custom mills at Fairbanks, are said to have contained a large amount of concentrates, but no statement as to their average gold tenor has been published. The property, not being in operation at the time of the writer's visit, was not examined, so the direction and the character of the veins were not determined.

Prindle reported in 1909 that auriferous quartz had been found in a shallow prospect pit sunk at an elevation of 1,775 feet near the head of Last Chance Creek. No work has been done on this property recently. Farther west, at an elevation of 1,400 feet, near the forks of Little Eldorado Creek, Prindle noted in 1909 a short tunnel trending S. 15° E. Some work has been done at this place more recently, but the claim was not visited by the writer, and details concerning it are lacking. At an indefinitely located point near the head of Spruce Creek a lode said to carry about $12 a ton in gold is reported to have been opened up by a shaft 150 feet deep. This property was not seen by the writer, and no further information concerning it was obtained.

DOME CREEK VALLEY.

RELIANCE MINING CO.'S CLAIMS.

The northern slope at the head of Dome Creek valley is covered by claims belonging to the Reliance Mining Co. and to people interested in that company. These claims form two parallel series. The northern series, named from west to east, comprises the La Rose, Wild Rose, Soo, Waterbury, Carnation, and Inspiration claims; and the southern series, which extends from a point near the middle of

the southern line of the Soo to the middle of the southern line of the Carnation, consists of the Waverly and Chief claims (fig. 5). Three main veins have been found on these properties, two trending nearly east and west and dipping north, and the third trending N. 50° E. and dipping 50° NW. The northern of the east-west veins is called the Soo vein and the southern the Wild Rose vein. The two converge toward the east, so that whereas near the west end line of the Soo claim they are 135 feet apart, at the east end line of that claim they are 60 feet apart, and at the end line between the Waterbury and Carnation claims they are said to be less than 20 feet apart.

Of these three veins the Wild Rose has been most developed and has yielded the greatest amount of gold. An inclined shaft on the end line between the Wild Rose and Soo claims has been sunk 100 feet and drifts have been turned off to the east at the 50-foot level and at the bottom. Much ore has been stoped from the upper level and milled. The vein followed by the drift at the bottom of the shaft is said to be a spur from the main vein, and the latter is supposed to be in the rock on the footwall side. Twenty-five feet east of the collar of the shaft an open cut has been made on the vein and the ore has been stoped out underhand.

A little southeast of the open cut a tunnel was driven eastward for about 100 feet, to a point where it intersected the vein exposed in the shaft and open cut, and from that point a drift was turned back at an acute angle westward on the vein and the ore stoped out for about 35 feet. The drift was carried eastward from the intersection of the tunnel and the vein for about 100 feet to a cross vein trending about northeast-southwest and dipping 40° SE. Where it was first cut this cross vein was very narrow, but at the bottom of a winze 20 feet deep, sunk near the intersection of the veins, it was 3 feet wide. The east-west vein is sharply cut off by the cross vein, and its continuation in the rock on the hanging-wall side of the latter has not yet been found. The wall rocks of the cross vein are much slickensided, but the amount of movement can not be determined.

The main openings on the northern vein, the Soo, are on the end line between the Waterbury and Soo claims and near the center of the Soo. At the end line a shaft 100 feet deep has been sunk and a short drift turned off to the west. The vein dips about 68° N. In the center of the Soo claim a tunnel, now caved, crosscuts the northern vein. On the end line between the Waterbury and Carnation claims, near the 1,800-foot saddle on the ridge running west from Pedro Dome, several shallow surface pits have disclosed quartz float that is believed to have come from the vein, but no mining has been done at this place.

The so-called Chief vein, which trends N. 50° E., traverses parts of the Waterbury, Chief, and Carnation claims. It has been opened up at several places by shallow surface pits, but these have caved so badly that the vein could be seen in only one of them—a 20-foot shaft at an elevation of about 1,900 feet. This vein is nearly parallel to the cross vein in the eastern tunnel near the shaft on the line between the Wild Rose and Soo claims, but it dips northwest, whereas the cross vein dips southeast.

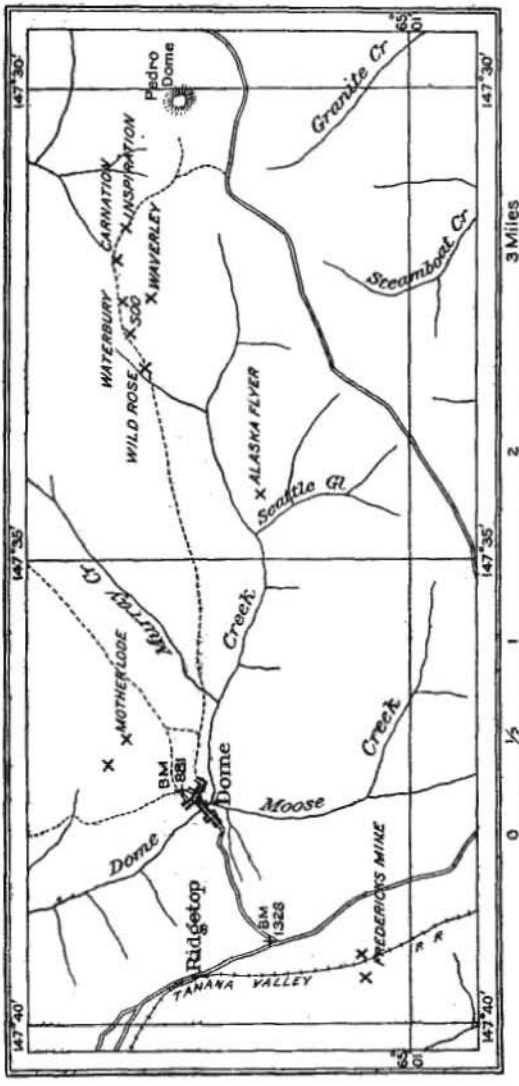


FIGURE 5.—Sketch map showing location of lode prospects in Dome Creek valley and near Ridgetop.

The specimens of ore taken from all these claims are strikingly alike, the ore from separate pits showing no greater differences than the ore from different parts of the same pit or drift. Much of the quartz has been subjected to shearing, so that it is "sliced" and its individual plates are elongated lenses. Crystalline quartz occurs in considerable amounts, not only in small drusy cavities, but also elsewhere in larger amounts, producing a typical "comb" structure. In one specimen, which was taken from the dump and whose location in place is consequently not known, a small stringer of crystalline quartz occurs between schist and a feldspar-quartz igneous rock.

Gold is practically the only valuable mineral in the ore. It is very bright and commonly occurs in crystalline aggregates, some of it in the midst of hard, glassy quartz, some in the more porous zones near

the schist, some in the cracks and crevices between the fractured quartz grains, and some on quartz crystals that project into drusy cavities. It appears to have been introduced at different times, but there is little question that much of it was deposited contemporaneously with the rest of the vein material as free gold and was not leached from sulphides by surficial processes. At several places where faults occur the gold has been dragged out and forms thin metallic plates on the slickensided surface, showing plainly that it was in the vein prior to the faulting.

The richest gold ore is reported to occur in shoots that pitch eastward. This is the direction of dip of the cross vein in the tunnel noted on page 177, and it is by no means improbable that the shattering incident to the movement parallel to the fault occupied by this vein may have opened up the older vein and permitted the access of new gold-bearing solutions. Whether or not this interpretation is correct, the older vein is said to be much richer near its contact with the northeast-southwest vein. These shoots, of which at least two are known in the present workings on the Soo, are reported to be ab[illegible] 20 feet wide.

Several determinations by local assayers and by the Selby Smelting & Refining Co., of San Francisco, show that the gold has a fineness ranging from 0.823 to 0.843. An assay made by the San Francisco firm of a 50-ounce sample of bullion gives 824½ parts of gold and 149 parts of silver. This indicates that the bullion is worth a little more than $17 an ounce.

Sulphides form but a small part of the vein material. A small amount of stibnite occurs in many places and some large masses are reported; none were seen, however, and their relations to the vein were not determined. In addition to the more usual sulphides, the vein contains small quantities of tetrahedrite (sulphide of silver, copper, and antimony), with which some gold is intimately mixed, the two having been deposited contemporaneously. Copper sulphides are extremely rare.

The gold tenor of the ore, estimated from the material now being mined, is very high. Much of the ore treated at the local mills has yielded $50 to $60 or even more to the ton, and mill runs on 8 to 10 tons of ore from the richest portions of the vein have given returns of over $250 a ton in gold.

The ore from this property was formerly treated at one of the custom mills, but in 1912 a small 3-stamp mill of local manufacture was installed. This mill, which is equipped with 250-pound stamps and has a capacity of only about 3 tons of ore a day, is situated near the Wild Rose–Soo shaft. Water is supplied mainly by pumping from a sump at the bottom of the shaft; and at that elevation so little is available that it has not been possible to run the mill more than a

few hours a day. The ore as delivered from the mine is cobbed by hand before it is delivered to the hopper for automatic discharge to the battery. It is crushed in the stamps to 30 mesh and is then passed over the plates. No appliance is used for collecting the concentrates, the pulp being discharged directly from the lower end of the plates.

According to the manager, nearly 80 per cent of the gold recovered is caught in the mortar box, the remaining 20 per cent being found on the plates. All the gold amalgamates readily, and little or no base material is present to contaminate the mercury. Though no determination of the amount of gold lost has been made, the amount of free gold lost in the tailings is probably small, for the lower end of the plates is very clean, but a good deal of the gold in the sulphides and other heavy minerals is probably lost.

The present site of the mill is so disadvantageous that a new site has been chosen on Dome Creek below the mine, and a new mill, equipped with two Nissen stamps, is expected to be in operation by [redacted]lose of 1912. Although this situation will necessitate tramming [redacted]ore for some distance, the advantage of a continuous supply of water should more than offset this charge.

MISCELLANEOUS PROPERTIES.

On the ridge between Dome Creek and the lower tributary of Seattle Gulch, at an elevation of about 1,200 feet, a 30-foot shaft has been put down on the Alaska Flyer claim. Not enough work has been done to indicate the nature of the ore, but it is reported that auriferous quartz has been found and that further prospecting will be done.

Half a mile northeast of Dome City, at an elevation of about 1,000 feet, some prospecting has been done at two shafts sunk on the Mother Lode and contiguous claims. The western shaft was 147 feet deep, and at its bottom a short crosscut was run eastward. The eastern shaft, 200 paces east of the western, was sunk 215 feet, the first 60 feet through muck and the rest through rock, no gravel intervening. In 1912 both shafts were almost filled with water, so that the underground workings were inaccessible, but the material on the dump indicates that no lodes similar to those now productive in the region have been found. The material is interesting, however, as it shows a somewhat graphitic limestone rather heavily impregnated with disseminated sulphides. The metallic mineral is mainly iron pyrite, but the rock also contains a little copper pyrite and some arsenopyrite. Some faulting has occurred subsequent to the deposition of the sulphides, for well-polished planes with mirror-like surfaces formed by both sulphides and country rock are by no means uncommon.

VAULT CREEK VALLEY.

FREDERICKS MINE.

About a mile south of Ridgetop, on the eastern slope of Vault Creek valley, are claims forming what is locally known as the Fredericks mine. (See fig. 5, p. 178.) This property has been developed by two shafts—the western, at an elevation of about 1,225 feet, and the eastern, at an elevation of about 1,350 feet—both sunk on the same vein. The vein strikes approximately N. 70° W. and dips north at varying angles.

The western shaft is a little more than 300 feet deep. At the surface the dip of the vein is about 70° N., but at the bottom it is about 45°. On the 100-foot level a 50-foot drift has been turned off to the east. The vein in the face of the drift is about 3½ feet wide, but as the adjacent shattered schist is also mineralized, a somewhat greater thickness of rock may be profitably removed in mining. The junction between the vein and the schist on the hanging-wall side is a smooth fault plane. From the other side of the shaft, at the same level, in a 15-foot drift extending west, the width of the vein changes abruptly and much of the material mined seems to represent merely a shattered zone in the country rock. Some stibnite occurs in the ore and is apparently more abundant toward the foot than toward the hanging wall.

On the 200-foot level drifts have been run 120 feet east and 30 feet west. The vein appears rather weak and in places the quartz is merely of knife-blade thickness. The iron-stained shattered zone, however, continues with a width of several feet. A crosscut has been driven into the hanging wall and a granitic rock disclosed at a distance of about 50 feet from the shaft.

Below the 200-foot level the dip decreases greatly until, at the bottom of the shaft, as previously noted, it is about 45°. On the 300-foot level a short drift has been turned off to the west. A crosscut into the hanging wall, however, affords the best available information as to the geologic conditions. The wall of the lead, which was followed by the shaft, is, as in the upper levels, a smooth, slickensided plane developed on a hard quartzitic rock which appears to have been affected by contact metamorphism. A few feet north of this plane is a sharp break, marked by a much slickensided surface on which the striations are vertical, beyond which is a fine-grained granitic dike about 7 feet wide, bounded on the north by another fault plane. The granite is so much decomposed that it is almost impossible to pick up pieces of it. Most of it is light colored, but it weathers to a rusty yellow, small dark spots here and there representing the ferromagnesian minerals it originally contained. Beyond the northern fault is a dark, greasy, and somewhat graphitic schist showing innumerable small slip faults, which trend in all directions,

but are broadly parallel with the dike. Though the underground workings do not show the deposit sufficiently to permit the solution of many of the problems, they give the impression that much of the material regarded as ore has been mineralized through its propinquity to the granite.

In the eastern shaft, which is 100 feet deep, the dip of the vein is about 80° at the surface and does not materially decrease in depth. No granite was recognized underground or on the dump, but there is a hard compact rock that probably belongs to the group of greenstones. Mineralization seems to have taken place along a shattered zone and to have impregnated the rocks in the vicinity. This zone dips much more steeply than the country rock and consequently traverses different rocks in different parts of the mine. Most of the material penetrated by the shaft is a brown, heavily iron-stained quartzose rock. This rock is very different from the auriferous veins so far described and appears to be a brecciated and mineralized schist rather than a distinct vein. Here and there in this broken-up material are small vugs containing quartz crystals, many of which are coated with oxide of manganese.

MISCELLANEOUS PROPERTIES.

None of the other properties in the Vault Creek basin were examined by the writer during 1912. Brooks[1] writes:

> It is said that about 280 feet of shaft and 60 feet of drifting was done on a property near the divide between Wildcat and Vault creeks, owned by Hoel Bros., Johnson & Witmer. Current reports are to the effect that a 30-foot ledge carrying low gold values and a richer vein 8 inches to 2 feet in width have been found on this property.

Ore from a property near Ridgetop, owned by Charles Thrift, is reported to have been milled at Fairbanks and to have yielded $11 a ton in gold. No details of the manner of occurrence were learned. No active work appears to have been in progress during 1912.

In the basin of the first tributary of Treasure Creek from the south, west of Independence Creek, two lodes have been exploited, but according to available reports no considerable amount of development work has been done. Near the mouth of this creek, on the eastern slope of the valley, a gold lode is reported to have been located, and south of it, near the head of the basin, a lode carrying mainly stibnite was found. Specimens of the ore from both localities were seen and appeared to be of high grade. Some silver minerals are reported to occur in the lode, but their composition was not determined.

GOLDSTREAM VALLEY.

WEST OF TWIN CREEK.

Several lode prospects were examined in the Goldstream basin at the head of Sheep Creek, near the summit of Ester Dome. (See

[1] Brooks, A. H., The mining industry in 1911: U. S. Geol. Survey Bull. 520, p. 32, 1912.

fig. 7, p. 190.) Interest in prospecting at this place was excited mainly by the finding at an elevation of about 1,950 feet, in the saddle nearly north of the triangulation signal on the summit of the dome, of a large quartz bowlder liberally splotched with gold. This bowlder, which lay on the surface, measured about 3 by 2 by 1 to 1½ feet. Most of it is hard, white, glassy quartz, which, according to reports of prospectors who have sampled it, carries no gold. On one face, however, it is peppered with particles of gold, some of which are a quarter of an inch in diameter. It is suggested that the auriferous part may represent one wall of a vein formed subsequently to the main mass of the quartz.

When the bowlder was found the region was visited and staked, and several pits were put down. In the same saddle two claims, the Blue Bonanza and the Midnight Sun, were located, and an inclined shaft with a slope of 35° has been sunk near the end line between them. In the upper part of the shaft an 18-inch vein of quartz was discovered, but it gradually narrowed with depth until at the bottom it was less than a quarter of an inch wide. There are several fractures, however, which the owners intend to follow farther, in the hope that the ore body will again widen.

Two distinct periods of quartz-vein formation are apparent at this place. The older quartz is considerably crushed and contains cavities opened since the crushing. The younger quartz is most readily recognized by its well-formed glassy crystals and by its banded structure, parallel to the walls. The younger veins contain considerable quantities of sulphides, mainly galena, pyrite, and some stibnite, which occur predominantly along the walls parallel to the vein and in the interstices between the well-formed quartz crystals. Where weathering has broken down the sulphides in the younger veins the quartz is covered with a thick coating of iron oxide. Gold is here and there visible in the rock both near to and remote from the areas of sulphides. Without doubt, the gold seen in some specimens of the ore was introduced contemporaneously with the sulphides, but that seen in other specimens was probably introduced earlier.

Considerable silver occurs in the ore. One of the owners reported obtaining 3 grains of silver and 1 grain of gold from an ounce of rock. Tests in the laboratory of the Survey prove the silver mineral to be tetrahedrite, a sulphide of silver, copper, and antimony.

Half a mile south of the shaft just described, at an elevation of about 2,325 feet, an open cut and an inclined shaft about 12 feet deep exposes what seems to be a large body of mineralized quartz, the tenor of which is probably low, although samples have not been carefully tested. The vein trends about north and south and dips about 45° E. Not more than a quarter of a mile south of this place, near the 2,375-foot pinnacle, more or less lens-shaped masses of quartz,

some of them over 6 feet in diameter, are exposed in a zone running north and south. The quartz is compact, little shattered, and glassy and does not look particularly promising. Little work has been done at this place, although a large amount of quartz has been broken down and scattered around.

Immediately west of the signal on the top of Ester Dome, at an elevation of about 2,425 feet, a vein known as the Farmer lode, trending north and south and dipping about 40° E., has been disclosed in an inclined shaft about 15 feet deep. The vein cuts the schists and is in turn cut by many small faults. It appears to be lens shaped, for it tapers out toward the bottom and toward the north wall of the cut. Sulphides, most commonly pyrites, are present, though not abundant. Gold is visible in the rock in a quantity which, though not accurately determined, is sufficient to warrant further prospecting and sampling.

A quartz vein reported to have been found on the southeastern slope of Sheep Creek valley at an elevation of about 1,500 feet was not visited by the writer, and no accurate data as to it were procured.

In the Goldstream basin between Big Eldorado and Twin creeks little lode mining has been done, and none of the several properties have been visited by the writer. In the Engineer Creek basin prospecting has been done near the divide between that stream and Columbia Creek and on Little Blanche Creek, a tributary of Engineer Creek. Near the head of Fox Creek Freeman & Sharf, it is reported, opened up a vein carrying considerable silver-bearing galena, as well as gold, and near the mouth of that stream a gold lode has been prospected. A lode has been located by Isaac Ogram on Rose Creek, a tributary of Gilmore Creek, and a lead carrying considerable galena and stibnite has been opened up by John Nightingale in Steamboat Creek valley. Near the head of Granite Creek Busch & Anderson have been prospecting a vein from which 4½ tons of ore are said to have been tested at one of the customs mills. No statement as to its gold tenor was procured.

TWIN CREEK VALLEY.

Rainbow mine.—North of the junction of Skoogy and Twin creeks, at an elevation of 1,700 feet, a shaft has been sunk on the Rainbow claim (fig. 6) on a vein that trends nearly east and west and stands practically vertical, its dip being in most places more than 89° S. The lode has been prospected by means of shallow pits for several hundred feet, and in this distance it is apparently unfaulted and fairly uniform in character. Most of the country rock is schist, but in a pit 300 feet east of the shaft the vein clearly cuts fine-grained nonporphyritic granite with a sharply defined contact.

The shaft is vertical and is 100 feet deep, and drifts 125 feet and 145 feet long, respectively, have been turned off from it to the east and to the west. In the eastern drift the vein is very regular in width, direction, and composition. It cuts across the country rock, which here consists of schists and quartzites. Both walls are well defined and are marked by fault planes. The rock stands well, so that no timbering is necessary in the drift.

In the western drift the conditions are more complex. A short distance from the shaft a narrow granite dike, dipping 40° E., appears in the footwall. This dike cuts across a small quartz stringer, which dips westward, but the dike is in turn cut by the main lode and has not been found on the hanging-wall side. Evidently it was

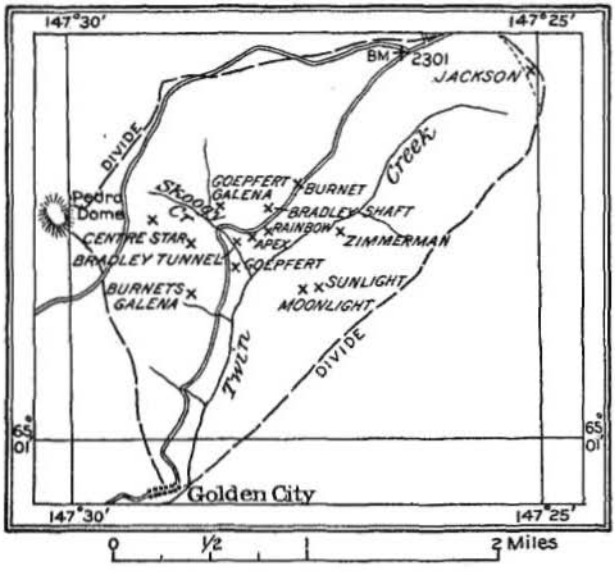


FIGURE 6.—Sketch map showing location of lode prospects in Twin and Skoogy Creek valleys.

faulted before the main vein was formed. On the walls of the dike is some quartz which marks the most acidic phase of the igneous rock. The granite is so badly decomposed that it falls to pieces when handled, and on account of its softness small slides have occurred at places where the ore rested on the granite as a footwall, leaving open spaces less than a foot wide and 2 to 3 feet long.

The country rock for a short distance west of the small granite dike is schist and quartzite, but for 40 feet farther west along the footwall it is a soft greasy white gougelike material which flows almost like clay. This material looks like a thoroughly decomposed granite, but tests show that most of it is a finely comminuted quartz and that only a small amount of it is aluminous. Still farther west

the main lode is transected by a small fault which offsets it about a foot to the south. Beyond this fault, which is near the end of the drift, granite, apparently part of a considerable mass, is seen in the hanging wall and in the roof on the footwall. Near the margin of the granite on the hanging wall is a border phase of quartzitic material which has apparently been produced by contact metamorphism. This granite clearly was earlier than the ore and had been cooled, consolidated, and faulted before the vein filling was introduced.

The richest ore of the Rainbow mine is reported to occur in a shoot which dips about 45° E. Too little development work has been done to show whether this dip is general or is characteristic only of the single shoot that has been found. The parallelism of the shoot and the small granite dike noted in the west drift near the breast, however, suggests some genetic connection between the two.

The vein material carries, in addition to the more or less glassy quartz, a considerable amount of sulphides. Pyrite, arsenopyrite, galena, and sphalerite have been recognized in it, and possibly some others might be detected by chemical tests. The sulphides are almost entirely confined to the vein material, but in a few places they occur in the country rock. In such places the sulphide is generally pyrite in sharply crystalline unoxidized cubes. Visible gold is rather rare, though the owners of the mine report that the value of the ore lies in its free gold and that the sulphides do not carry much gold. The average tenor of the ore is not known with certainty. A mill run of a sample of 19 tons of ore is reported to have shown a gold content worth $38 a ton, but this was probably selected material. The fineness of the gold as determined in two assays reported by F. W. Hawkins is 0.838½ and 0.839½.

The machinery for a two-stamp Nissen mill was expected to arrive before the close of 1912. Much more underground development will be necessary before the veins can furnish a constant supply of ore for the mill.

Properties east of the Rainbow mine.—A short distance northeast of the Rainbow mine, at an elevation of about 1,825 feet, a 10-foot shaft has disclosed a 2-foot quartz vein which appears favorable for further exploitation. The vein strikes nearly east and west and dips steeply south. The ore is mainly shattered and sheared milky quartz containing only a small amount of sulphides.

Near the road a quarter of a mile east of this shaft, at an elevation of 1,975 feet, is a small pit which has been abandoned for some time. Coarse gold is reported to have been found in the slide rock near the surface, but at the time of visit the pit had caved so badly that it was impossible to determine whether there was at this locality a definite lead in place.

On the Moonlight claim, at an elevation of 1,900 feet on the southern slope of the valley, is a shaft about 50 feet deep from which has been turned off a 15-foot drift. The vein here rolls a little, but has a fairly steep dip to the north. It is about a foot wide and is said to carry considerable gold in some of the slip seams. The quartz is broken into wedge-shaped blocks, the thin edges of which overlap. No faults were seen in the small portion of the vein so far uncovered. The vein material is mainly quartz with a large amount of sulphides, and the country rock is quartzite schist. Prospect pits have been sunk at intervals west of the shaft, and vein material can be traced to the granite area above the junction of Twin and Skoogy creeks. East of the shaft, along this same trend, the Sunlight claim has been staked. Little work has been done on this claim, though, according to report, the vein has been located on it by means of shallow prospect pits.

North of the Moonlight lode a claim has been staked by Zimmerman and others on the supposed continuation of the Rainbow lode, and a short open cut has been run into the hillside south of Twin Creek at an elevation of about 1,700 feet. The strike of the lode is not constant, appearing to swing from east-west toward north-south, and the dip also changes from north to east. Assays of ore from the dump containing considerable sulphide-bearing material are said to have given returns of $12 in silver and $4 in gold to the ton. Under present conditions ore of this tenor can not be profitably treated in this region.

At the extreme head of Twin Creek W. Jackson and others have sunk a number of prospect holes. In a pit above the road, at an elevation of about 2,500 feet, a large amount of quartz cuts the greenstone-like schists that form the country rock. The quartz shows almost no sulphide mineralization. No trustworthy determinations of the extent or tenor of this lead have been made. It is probable, however, that its gold tenor is low, for the quartz differs decidedly in appearance from that in the rich lodes.

Properties west of the Rainbow mine.—The Apex claim, which lies adjacent to the Rainbow mine on the west, has been prospected by shallow pits that have revealed a vein having an eastward-dipping shoot of ore, apparently the extension of the Rainbow lead. No ore has been produced from this property, and not enough development work has been done to expose the vein satisfactorily. The proximity of the lead to the granite indicates that granite will probably be encountered in the underground workings a rather short distance below the surface.

In the granite area, near its northern contact with the schist, at the mouth of Skoogy Gulch, Peter Goepfert has driven a short adit on a nearly vertical 2-inch stringer of quartz which appears to cut

the granite. No ore has been milled from this property, and although the material is said to carry some free gold, it looks barren.

A short distance up Skoogy Gulch, below the road crossing, a tunnel about 200 feet long has been driven N. 10° E. According to report, much of the material encountered in this tunnel is mineralized, but except for a few stringers and immediately at the face there is no distinct vein. The small stringers are transverse to the direction of the tunnel. At the end of the tunnel a strongly marked fault plane trends about east and west and dips steeply north. South of the fault there is from 6 to 8 inches of vein material, which, however, has not been tested for gold. Some gouge occurs along the fault.

Still farther up Skoogy Gulch, at an elevation of 1,750 feet, a short tunnel has been driven on a ledge said to carry considerable galena. This property was not examined in 1912, as no work was in progress. Another galena lode is said to have been found west of Skoogy Gulch at an elevation of about 1,725 feet, near the northern contact of the southern granite mass. The ore is reported to lie nearly flat, but this attitude is said to be due to downhill creep, and prospecting has not yet progressed far enough to disclose the real trend of the lead.

On the hillside west of Skoogy Gulch considerable prospecting has been done in the past, but during the summer of 1912 no mining was in progress on any of the claims. The shafts and tunnels were no longer accessible, and the following statements have been taken from reports by Prindle,[1] who visited the region in 1909, when some work was being done.

The prospects in Skoogy Gulch, including the North Star, Center Star, S. S., and other locations, are all in schist close to intrusive rocks. * * * The rock in which the mining developments have been carried out is quartzite schist and quartz-mica schist striking northeast. The rock is somewhat metamorphosed by the contact influence of the intrusive rocks, an influence shown by the presence of a large amount of biotite and some andalusite. While some of the schist is very micaceous, much of it is a dense blocky quartzite schist. A small dike about half an inch thick in one of the tunnels shows the closeness of the igneous influence.

Auriferous quartz veins are reported to have been traced on this [western] slope of Skoogy Gulch for 500 to 800 feet. At one locality, where surface prospecting in 1908 had discovered an auriferous stringer about 4 inches thick, together with several smaller auriferous stringers, some of them along the joint planes of the schist, a shaft about 65 feet deep and a tunnel about 200 feet long had revealed in 1909 a considerable number of stringers, some of them barren and some of them carrying high values.

The vein regarded as the main lode strikes northwest and is said to average about 3 feet in thickness. Several hundred feet farther in the same direction a shaft has been sunk on a vein 10 to 12 feet thick, which carries values.

The marginal portion of the porphyritic granite contains in places a large amount of iron pyrites in the granite itself and along the joint planes. Iron pyrites occurs simi-

[1] Prindle, L. M., op. cit., pp. 223-224.

larly along the joint planes of the schist at the locality of the auriferous quartz veins. The granite contains also some pegmatitic quartz and feldspar, occurring as feldspathic veins in quartz and quartz veins in feldspar. In some of these veins both margins are feldspar and the middle is quartz. The quartz present in these granitic products is gray and glassy. In the quartz veins that have been opened there is a similar gray, glassy quartz and this is apparently barren. The auriferous quartz is grayish white and opaque. The veins of both the barren quartz and the auriferous quartz contain a small amount of feldspar. This is mostly kaolinized, but so far as determined is like that of the pegmatitic granite dikes above mentioned. Cavities studded with quartz crystals are rather common in the quartz. The gold occurs partly in visible form embedded either with limonitized crystals of pyrite or in the quartz. The auriferous quartz contains a large number of microscopic liquid inclusions and so far as observed has been more or less shattered. Although it is possible that the auriferous pyrite and free gold were deposited synchronously with the quartz, it seems more probable that the deposition of gold was subsequent to a shattering of the quartz and synchronous with the deposition of pyrite along the joint planes in the schist and porphyritic granite.

TRIBUTARIES OF CRIPPLE CREEK.

ESTER CREEK VALLEY.

HUDSON MINE AND VICINITY.

In the Ester Creek valley (fig. 7) none of the prospects have yet been developed to a producing stage except the property locally known as the Hudson mine. This group of claims is on the ridge north of Ester Creek between Moose Gulch and Ready Bullion Creek, extending to an elevation of about 1,600 feet. The place where most of the mining has been done is at an elevation of about 1,500 feet. A shaft was sunk here, but in following the lead its course became so crooked that hoisting was difficult, so it was abandoned and a new shaft was sunk a short distance above. The new shaft is planned to intersect the old workings at a depth of 100 feet, but it will be continued below this depth and drifts will be turned off to open stoping ground. The new shaft, which is vertical, was sunk at the rate of about 3 feet a day.

Although the old shaft was no longer in use in 1912, it was still accessible and afforded the best insight into the character and mode of occurrence of the ore. To a depth of 40 feet the shaft is vertical, but from that depth downward the dip of the lead flattens, and an incline at an angle of 45°, turned off to the northwest, extends to a depth of about 94 feet. The lower part of the incline had caved a little and at the time of visit the ventilation was poor. Although all the rock is somewhat mineralized, there seems to be no well-defined lode. A fault plane on the east side of the shaft has apparently been taken as the footwall of the ore body, but so far as could be learned this plane is not a true footwall, for there is ore below it, and the only reason for considering it the footwall is that it forms a good surface to mine to. On this fault plane is a varying thickness

of gouge which shows well-marked striations, as does also the fault plane. Movement in many directions is indicated by the grooves and scratches.

The country rock is mainly a thinly laminated dark greasy-looking chloritic schist, with the laminæ minutely crinkled. Numerous small quartz veins, ranging from mere films, to stringers an inch or so thick, cut the schist at high angles. In addition to these narrow veins there are numerous larger masses of quartz having a more or less bowlder-

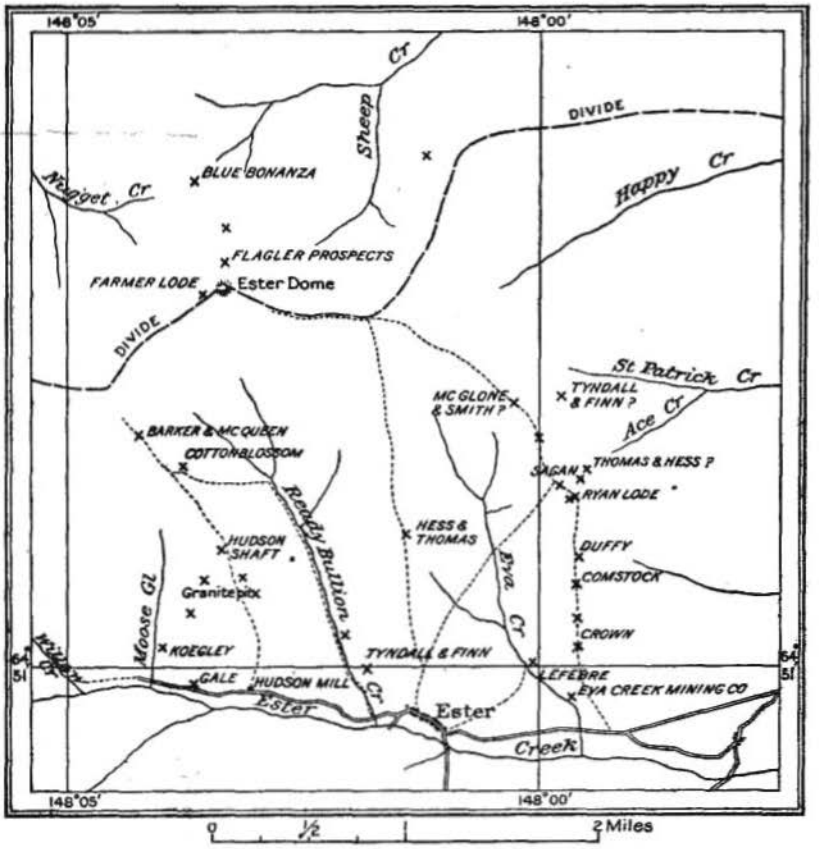


FIGURE 7.—Sketch map showing location of lode prospects in Ester Creek valley and vicinity.

like appearance. These masses are composed mainly of hard, glassy quartz, which is practically barren. Their surfaces are fairly smooth, are more or less completely enveloped in gouge, and are usually covered with slickensides. Probably many of these masses were formed by faulting, but some are probably old quartz lenses traversed by narrow younger veins.

At a few places quartzite forms the country rock. It is usually white or brownish and consists almost entirely of quartz. Silicifica-

tion has apparently affected the rock at a late stage, for recently deposited quartz covers many of the joint planes and extends from them into the rock. The brown quartzite is stained with limonite, formed apparently by the decomposition of pyrite, which is sparsely disseminated through the rock. All the quartzites suggest proximity to an igneous intrusive, but the evidence is by no means conclusive.

The richest ore of this mine occurs in the narrow quartz stringers which intersect the country rock in all directions. These stringers usually adhere firmly to the country rock, so that the whole material must be mined and milled. The gold in the stringers is usually in small particles, but in places these are large enough to be recognized, even underground, at a distance of 3 or 4 feet. Sulphides are practically absent from these veins and the gold occurs free. It is bright yellow and seems to be more abundant near the walls than in the center of a vein. In the centers of the small veins at many places are cavities into which perfectly formed quartz crystals project.

Although the gold occurs mainly in the narrow veins, numerous particles of gold were found by panning a sample of the country schist from which nearly all pieces of quartz had been picked. This result shows that some of the schist is auriferous, but most of it that lies remote from the small veins is believed to be practically barren.

No estimate of the tenor or extent of the material to be mined has been made. Although very high gold assays have been obtained from pieces of the small quartz veins, they are of little value in showing what the average ore will yield, for a large amount of schist and rock of low gold content must be treated when the mine is opened commercially. Before an expensive mining and milling plant is installed the tenor of the rock for the width that must be mined should be accurately determined.

At intervals on the hillside below the Hudson shaft are numerous prospect pits and several large quartz bowlders only partly buried in the moss. A prospect pit south and a little west of the main shaft at an elevation of 1,400 feet, shows at its west end dark schist similar to that in the mine. East of this schist is a reddish-brown, much-decomposed granitic rock, and this is followed toward the east by a seam of gouge and a well-marked fault plane, beyond which is more granitic material. The width of the exposure is only about 5 feet, so that the extent of the granitic rock to the east is not known, but apparently it is not great. Slickensides have been abundantly developed along the fault. The granitic material strongly resembles that at the Fredericks mine near Ridgetop, already described (pp. 181–182).

Although the underground workings have not yet been carried far enough to yield a constant supply of ore, a mill has been built on the north side of Ester Creek midway between Moose and Ready Bullion creeks. The construction work had been much delayed, but

the mill was expected to be in running order soon after the first of October. The building is large enough for twice the present installation, which consists of a battery of two Nissen stamps. Space has been reserved for concentrating tables, but they will not be put in for some time, as it is believed that most of the gold in the ore will be recovered in the mortar or on the plates. Water will be obtained from a well driven near the mill, which is believed by the owners to be capable of affording a sufficient supply throughout the year. The ore will be hauled by teams from the mine to the mill and stored in bins until required. The distance between the two places is about two-thirds of a mile and the difference in elevation is about 600 feet, the loaded wagons having a downhill haul.

On the north slope of Ester Creek valley, a fifth of a mile east of the mouth of Moose Gulch, a prospect pit 20 feet deep has been sunk on heavily iron-stained quartz and brown-weathering schist. The quartz is glassy and compact and appears to occur in small stringers in the schist, but many large pieces of quartz were seen on the dump. The material is reported to carry some gold.

A short distance above the ditch line on the eastern slope of Moose Creek valley, on the Koegley claim, a short tunnel has been driven in an area of mineralized schist cut by small quartz stringers. No strongly marked lead was followed, but here and there small quartz stringers and slips trending parallel with the tunnel have been found. According to men interested in the claim the small quartz stringers carry the most gold, but all the material traversed by the tunnel contains enough gold to warrant milling.

EVA CREEK BASIN.

Practically the whole of the Eva Creek basin is covered with quartz claim locations, and a great number of prospect pits have been sunk, particularly along the ridge, where the overburden is thinnest. Most of the holes have caved, however, and no longer afford exposures of the bedrock, and natural outcrops are practically absent. In the following notes only the more accessible prospects are described.

Half a mile north of the mouth of Eva Creek a quartz vein which trends about N. 60° W. and dips 68° SW. has been prospected. The easternmost opening on this lead is an abandoned tunnel. A 75-foot shaft was sunk above this tunnel, and a narrow, well-defined vein was found. A little to the northwest, on the same vein, an open cut about 40 feet above the stream had exposed the vein for nearly 100 feet and the ore had been stoped out. Short tunnels near the creek level have been driven to cut the vein, and most of the ore that could be easily won has been removed. The walls stand well, even without timbering, but to continue mining it will be necessary to install

a pump. The occurrence of the ore is more like that of the mines and prospects in the Chatanika basin than that of most of the other prospects in the Cripple Creek region.

A short distance farther up Eva Creek Hegan & Lefebre have driven a tunnel about 25 feet above the creek, on a vein which trends nearly north and south. In the breast of this tunnel are numerous flat-lying quartz lenses which are much crushed. About 8 feet from the face is a crosscutting fracture zone with some broken-up country rock and quartz. This seam is very narrow, and no statement of its gold tenor was obtained, but the owners are sinking on it.

Prospect pits are scattered all the way up the ridge east of Eva Creek, but only on the Ryan lode, at an elevation of about 1,325 feet, has any considerable work been done. Two shafts have been sunk on this property. The northern shaft is shallow and has been abandoned for some time. Practically all the material on the dump is quartz; there are almost no fragments of schist. The southern shaft is said to be over 90 feet deep, but in 1912 it had caved so much that the lower 30 feet was filled. The maximum width of the vein is about 16 inches. Near the bottom of the shaft the vein has been faulted, and it pinched out to the west. To judge from the direction in which the schists near the fault have been dragged, the continuation of the vein should probably be sought in the hanging wall above the point where the vein is cut off.

The rocks abutting on the fault are strongly slickensided, and although the grooves run in all directions, apparently the main movement was horizontal on the nearly vertical plane. Near the fault is considerable gouge, which seems to be ground-up material derived from the vein and the country rock. More or less parallel with the fault is a white, much-decomposed rock that resembles a thoroughly weathered granite. It consists mainly of quartz with subordinate amounts of feldspar, now altered to kaolin.

In the saddle northwest of the Ryan lode a shaft 30 feet deep disclosed auriferous material. At this place the whole rock seems to be mineralized, but no distinct vein with well-defined walls was found. The country rock is dark, much broken-up schist, containing numerous small quartz stringers. Although faults are common, they appear to have effected but a small amount of displacement. Sulphides are not abundant, although some of the ore is stained with limonite, probably derived from the decomposition of disseminated pyrite. A little of the vein matter, consisting of fine-grained quartz and feldspathic material, simulates a marginal phase of granite. The extent and distribution of rock of this kind, however, were not determined. All the material from this shaft is reported to show small amounts of gold when panned.

Near the head of Eva Creek, at an elevation of 1,600 feet, Edward Hess and others have sunk a 60-foot shaft on a quartz vein carrying considerable stibnite and disseminated sulphides. The quartz is fine grained, is granular, and has a grayish color, due to the sulphides that occur throughout it. The vein matter is similar in appearance to that from many of the Cleary Creek prospects already described. Visible gold is reported to be fairly common.

On the divide between Eva and Ready Bullion creeks, at an elevation of about 1,500 feet, a vein was found and prospected by Hess & Thomas. The country rock is a rather decomposed, dark, greasy-looking chloritic schist, cut by small quartz veins. The material on the dump is similar to that in the deposits with disseminated mineralization, previously noted as being the most common type in the Ester Creek region. No mining has been done at this place for some time.

READY BULLION BASIN.

In the lower part of the Ready Bullion basin several lode claims have been located by Tyndall & Finn, who have made many openings, most of which, except notably two adits near the creek, are now inaccessible. The southern of the two adits is east of the creek about a third of a mile above the mouth and is about 60 feet long. The vein it follows is small but well defined. The country rock adjacent to the lead is not much mineralized, and the gold is reported to occur entirely in the quartz vein. No work has been done at this place recently.

The northern adit lies about one-eighth of a mile farther upstream and is about 50 feet long. Not much ore was seen on the dump and no well-defined lead was found underground. After schist that was apparently in place had been penetrated for some distance, a mass of water-rounded pebbles an inch in diameter was found on the north side of the adit. The pebbles are overlain by flat-lying schist, which, though apparently in place, is probably a large piece of slide rock. The roof is not fissured, but the underlying rock is broken up and the fractures in it were evidently followed in prospecting. Many small quartz veins occur in the schist, but their gold tenor was not determined.

Some prospecting has been done on the Cottonblossom claim, west of Ready Bullion Creek, at an elevation of 1,750 feet. A 70-foot shaft was put down at this place, but in following the lead it became so crooked that it was abandoned, and in 1912 a new vertical shaft had been started and sunk 60 feet. Some trouble was experienced with water, but the ground is not very wet, as less than 20 buckets of water collects in over 12 hours. No definite lead was found at this

place, but there is a well-marked fault which is regarded as the footwall. Above the fault plane is several inches of gouge made of the comminuted country rock. The shaft was started on this material, but as the dip of the gouge flattened sinking was continued on small fractures and quartz stringers. Stibnite occurs in bunches near the surface and at the bottom of the shaft and is scattered sparingly through the quartz stringers. In the rock are numerous cavities left by the decomposition of sulphides, which probably originally carried some of the gold. A part of the gold, however, occurs in the very narrow quartz stringers. So far as can be seen at present the mineralization corresponds in general to that at the Hudson property, half a mile to the south, on the same ridge, though apparently the ore is not so rich.

At an elevation of 2,100 feet, on the same ridge, Barker & McQueen have prospected a quartz vein trending northwest-southeast and dipping steeply northeast. No work had been done on the property for more than a year, and although a good deal of quartz was seen on the dump its gold content is reported to be small. Sulphides are practically absent.

ST. PATRICK CREEK VALLEY.

A number of claims have been recorded in the St. Patrick Creek basin, but no mining was in progress at the time of the writer's visit. Most of the claims are on Ace Creek, the southern headwater branch of St. Patrick Creek, and on the ridge to the north. In this region most of the prospecting has been done by Thomas & Hess, Tyndall & Finn, and McGlone & Smith. It is said that shafts 100 feet deep have been sunk on some of these properties and promising veins discovered, but no production is reported.

The only pits in the St. Patrick Creek basin that were visited by the writer in 1912 are at the head of Ace Creek, immediately below the Ryan lode claim. These pits trend a little east of north, and in each of them heavy quartz float and ledge were found. One pit at an elevation of 1,175 feet disclosed a wide lead of quartz, huge bowlders of which were seen on the dump. The quartz is much crushed and faulted, the faulting in places producing polished surfaces that simulate cleavage. Several generations of quartz are present, one of the oldest being a dark chertlike quartz which has been fractured and later infiltrated by light-colored quartz. This in turn has been broken, and still more recent quartz has been introduced into it. Some cavities formed by the leaching out of sulphides occur irregularly through the quartz. Tests of the vein material are reported to have shown a low gold content.

MISCELLANEOUS PROSPECTS.

As has been stated, undoubtedly many places where lode prospecting has been carried on have been omitted from the foregoing description. There are, however, some claims whose location, though more or less indefinite, places them outside of the drainage basins already described. None of these claims were visited in 1912, but in order to make this report as complete as possible the few available notes on these properties are given.

Between the headwater branches of the tributary of Columbia Creek, at an elevation of about 875 feet, an adit 100 feet long is reported to have been driven on a quartz lead. The ore is said to be of low grade but free milling. Above this place are the prospectors who have been working at the head of Engineer Creek, in the Goldstream basin. According to report, the whole region forming the Columbia-Steele-Engineer divide has been covered with lode claim locations, and at least four different parties have been more or less actively prospecting for veins, but so far apparently without notable success.

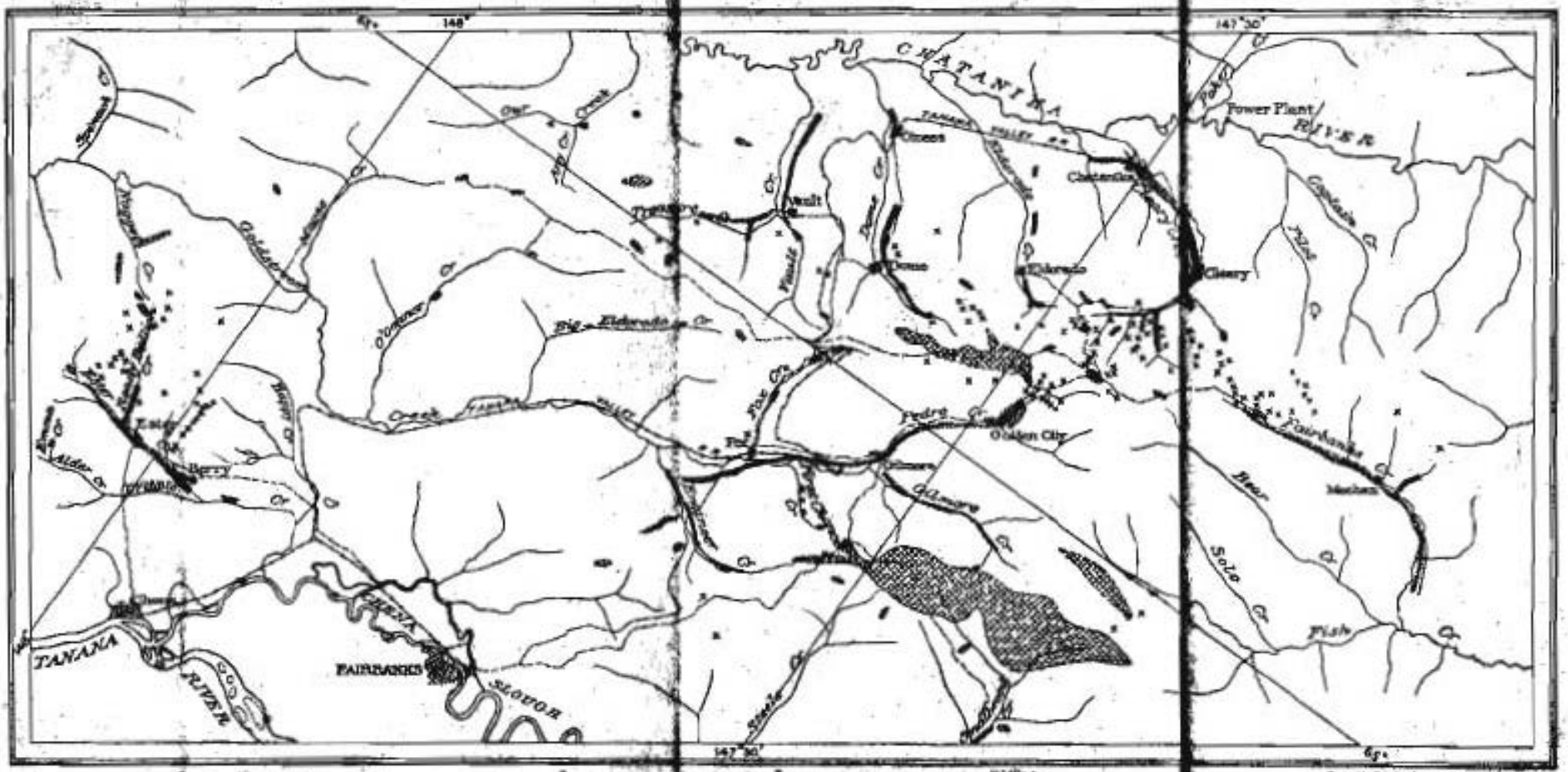
East of Steele Creek, on the ridge between that stream and Rex Creek, a tributary of Smallwood Creek, a little prospecting has been in progress. This work apparently was done mainly in the vicinity of the 1,825-foot hill. All the leads through this region are said to be wide, but the ore is of low grade and whether the properties can be profitably developed under present conditions is doubtful.

FUTURE OF LODE MINING.

In the earlier part of this report the mining developments in the vicinity of Fairbanks have been described with particular reference to the physical features of the veins and the extent and character of the work accomplished. There are, however, many other phases of the subject concerning which miners in the region or prospective investors wish to be informed. Many questions relating to these phases can not be satisfactorily answered, but it seems desirable at this place to set forth the inferences that may be drawn regarding the probable conditions, both geologic and commercial, to be expected in the future development of lodes in this region.

AREAL EXTENT OF MINERALIZATION.

Plate VI shows the places where gold-bearing lodes have been prospected and ore has been found. Whether this distribution of prospects truly represents the distribution of auriferous veins is a question of importance which can not yet be answered definitely. The two lines of available evidence lead to somewhat opposite conclusions. The rich placers are more or less closely con-


148°
147°30'
65°
CHATANIKA
RIVER
Power Plant
Fairbanks
Cleary
Vault
Dome
Eldorado
Olnes
Big Eldorado Cr
Gilmore
Ester
Goldstream
Fairbanks Cr
Solo Cr
Fish Cr
Creek
Alder Cr
Ester
Gilmore
Gilmore Cr
Fairbanks
Gilmore Dome
Ester Dome
Ester Creek
Goldstream Cr
Goldstream
Steele Cr
Steele
Slough
Slough Cr
Slough
Slough
Slough

fined to the streams that drain areas in which the most lode prospecting has been done, a fact which suggests that the auriferous lodes are more or less restricted to the prospected areas, though there are placers in parts of the Goldstream and other basins where lodes have not yet been discovered.

On the other hand, when deductions are based on the supposed origin of the auriferous lodes the conclusion is reached that the veins are much more widespread than the present lode prospecting. In order to explain why the origin of the veins throws light on the areal extent of mineralization, it is necessary to consider the theory advanced by Prindle.[1] According to this theory, the mineralization was closely connected in time with the intrusion of the granitic igneous rocks. It was due not only to the mechanical effects of the intrusion, which fractured the rocks and provided open spaces in which the minerals were deposited, but also to the introduction of the minerals, which were derived from a deep-seated source. If this explanation is correct, it follows that the areas near the intrusive granitic rocks are the places where lodes are most likely to occur. Outcrops of these igneous rocks are widely distributed throughout the Fairbanks region, and in many places where these rocks are not exposed they probably occur a relatively short distance below the surface. In fact, the territory adjacent to Fairbanks may reasonably be regarded as occupied by schists underlain by a large granitic mass from which igneous material protrudes in irregular apophyses, some of which have been revealed at the surface by erosion. It is believed, therefore, that auriferous veins may reasonably be expected to occur at many places where their presence has not yet been proved by prospecting.

LOWER LIMIT OF MINERALIZATION.

Although the intrusion of granitic material was more or less closely associated with the mineralization, neither process was a single event, as there were several periods both of intrusion and of mineralization. Prindle [2] states that the sequence of intrusion was in general quartz diorite, porphyritic biotite granite, and persilicic dikes. From studies both by Prindle and by the writer it has been determined that mineralization of at least two types may be recognized—that producing a series of older auriferous quartz veins and that producing a later sulphide-bearing series. In addition there are veins of a much earlier period, with which the present investigations are not concerned, for so far as known they are not auriferous. The fact that all the veins and all the igneous rocks were not contemporaneous indicates that certain veins may cut certain of the igneous rocks. This

[1] Prindle, L. M., U. S. Geol. Survey Bull. 525, pp. 89–92, 1913.
[2] Prindle, L. M., U. S. Geol. Survey Bull. 442, p. 216, 1910.

conclusion is significant in determining the depth to which the veins may extend, for it suggests that they may persist into the areas occupied by the granite and are not necessarily limited to the country rock adjacent to the intrusive masses. This suggestion is in accord with the field observations, for at several of the mines veins were found occupying fissures along faults by which granite dikes have been offset. Therefore, although the veins probably did not extend as distinct veins to the zone where the rocks were in a state of flowage, there is no valid reason for placing the lower limit of vein formation above the surface of the granite, and some of the veins may reach a depth regarded by miners as considerable.

CHARACTER OF MINERALIZATION IN DEPTH.

The tenor of the ore and its physical character in the accessible surface portions can be examined and the commercial return that can be obtained by development of the deposit may be calculated with some degree of mathematical precision. It is important, however, to determine to what depth the several factors bearing on the problem, notably the chemical composition of the ore, are applicable. This is particularly true of auriferous quartz veins, which near the surface carry gold mainly in the native state. From such veins the gold can be recovered by simple processes of crushing and concentration. If, on the other hand, the gold in the unweathered ore is mainly in a state of chemical combination or mechanical suspension in particles so finely disseminated that its recovery necessitates metallurgical treatment, it may not warrant mining, even though it may be as abundant as in the free-milling ore.

It has already been stated that at least two distinct types of mineralization have been recognized in the shallow surface portions of the veins so far exploited. Each of these types requires separate description and the facts concerning one do not necessarily apply to the other. Failure to discriminate between the two has led to certain misconceptions. Not enough data have yet been gathered to determine with finality the character of the ore in depth, and the following statements are therefore tentative.

So far as determined the non sulphide-bearing auriferous quartz veins contain gold in a native state as an original constituent, and this is interpreted as indicating that to a moderate depth below the surface these veins are of approximately uniform composition. In other words, it is believed that to the depth which will probably be reached in mining in the near future the gold in the older auriferous quartz veins is free milling.

In the sulphide-bearing veins visible native gold was introduced contemporaneously with the sulphides and probably these minerals also carry a considerable amount of gold so finely divided as to be

invisible. Under present milling practices the invisible gold is not recovered and its proportion to the visible gold is unknown. There are, therefore, no data as to the quantity of gold carried by the sulphides at different depths in the 300 feet to which mining has been carried below the surface, and deductions as to the conditions at still lower levels are therefore practically guesses. It should be realized that in veins of this type some of the gold in the surface portion is probably derived from broken-down sulphides and that this portion therefore contains more gold than can be recovered from unweathered ore from lower levels by milling without metallurgical processes, so that the average deep ore probably will not yield as much gold as that obtained nearer the surface.

In several of the mines examined veins of both types occur together. In some of these places the older vein had been fractured and later solutions of the sulphide-bearing type had been introduced. Where this happened the average gold content of the rock was increased and a rich shoot resulted. There is no reason why this condition should not occur also in the deeper parts of the deposit. In fact, it is possible that in the deeper parts the older quartz veins were more brittle than the other rocks, and therefore were especially susceptible to fracturing, and allowed the later solutions to pass through. This suggestion, however, is based on so many rather indefinite assumptions that it is of little practical value and should serve only to indicate that to a moderate depth there is probably no marked decrease in the number of intersections of veins belonging to the two different periods.

TENOR OF THE ORE.

Statements of the value of the ore mined at the present time range all the way from a few dollars to more than a thousand dollars a ton. Many of these statements are based on assays of small selected specimens and have no general application. None of the private mills have made returns of the tenor of the ore that are available for publication, so that the average value of the ore mined is not known. The records of the Fairbanks test mill show that the average tenor of the 64 tons of ore from 24 different properties milled in the first three months of 1912 was $69.87. (See p. 165.) It was reported that the 292 tons from five different properties milled at the Chena mill in 1911 yielded an average gold content worth $106.80 a ton. These results undoubtedly represent selected ore and consequently are higher than would be obtained in ordinary commercial practice if the mines were in constant operation. It seems certain, however, that the average vein material from many of the mines now in operation, if kept reasonably free from waste in mining, will run about $50 a ton. This estimate includes the free gold only, for, except at two or three

mills, no concentrates are saved, though they undoubtedly contain additional gold.

Ore with these high gold values comes mainly from small quartz veins, many of which are only a foot or so in width. There are in the district, however, larger veins, some of which are as much as 15 feet wide. Some of these have been sampled and are said to yield from $10 to $15 a ton in gold. Under present mining costs ore of this low tenor can not be commercially developed in this region. With the reduction of expenses which may reasonably be expected, these low-grade deposits may possibly be developed profitably on a large scale.

It is undoubtedly true that at present only the richest parts of the veins are being mined. With the opening of the deposits on a large scale, undoubtedly the tenor of the ore milled will decrease. In large measure this will be due to improvements in milling practice through which lower-grade ore can be treated at a profit, but it will be due also to actual decrease in the tenor of the veins with increasing depth. The extent of this decrease is not known, though it now seems probable that, factors other than depth being eliminated, the veins should contain nearly as much gold at the depth which will be reached in the near future by mining as they do a few score feet below the surface.

MINING COSTS.

GENERAL EXPENSES.

At the present time, owing to the remote position of the district, its partial isolation during the winter, and its lack of productive occupations during the months when the surface water and the ground are frozen, the costs of supplies and wages are high. With the development of the region many of these disadvantages will be decreased or removed, so that a decided reduction in operating and living expenses is expected. Thus, when lode mining increases, many persons will find permanent employment throughout the year and will no longer be compelled to remain idle during the seven or eight months that the placer mines are closed. Moreover, if business increased, transportation facilities could be improved and charges could be reduced without affecting the profits. So many factors enter into the problem, and they interact so intricately, that the evaluation of the separate items which bear on the future mining costs in the district is impossible; but as a whole the costs will tend to decrease rather than increase.

COST OF POWER.

Although, on the whole, the general trend of costs will be downward, special expenses to which small mines are not subject will become more and more necessary as larger mines are developed. The

most notable expense of this class is that for power. As long as the mines are shallow or are accessible from hillside tunnels little power other than that of man is necessary in mining, for underground drilling is done by hand drills, the ore and waste are removed by a man and windlass or by hand tramming, and water is kept away from the workings by allowing it to run off along the slope of the tunnel or by hoisting it with a windlass.

With increasing depth, however, power for pumping and hoisting becomes more and more necessary, not only on account of the larger amount of material that must be handled, but also of the longer distance the same amount of material must be moved. In the matter of pumping, which has given a number of operators concern, probably the greatest amount of water will be found in the surface zone. Proportionally more water will occur within the first few hundred feet than lower down, but with increased depth the water must be lifted a greater distance and will be more troublesome and more expensive to handle. Therefore, although existing conditions indicate that probably most of the mines will not be excessively wet, charges for pumping must be anticipated and provided for.

As the determination of the amount of water that may be expected in depth is a matter of considerable importance the following reasons for believing that under ordinary conditions the amount will not be excessive are given: First, the average mean annual precipitation at Fairbanks for the years 1906 to 1910, inclusive, was only 11.13 inches, and although precipitation is probably greater in the higher areas, it is nevertheless small; second, the frozen condition of the surficial parts of the deposits prevents much ground-water storage and increases the rapidity of run-off; third, except in the surficial portions the rocks are rather impervious and afford few channels for the passage of water underground; fourth, in practically all the underground work examined no considerable amount of water has been encountered.

At present power for various purposes at the mines and mills where machinery is used is produced from wood or gasoline as fuel. Timber near the mines is not abundant and is becoming scarcer, so that although in favorable places wood is sold for $5 a cord most of the mines pay about $15 a cord. All the gasoline used comes from the States and costs 60 cents or more a gallon at the mines. No coal is used as fuel, though there is a large amount of lignite 60 to 100 miles distant. Plans have been considered for utilizing this coal either by transporting it to Fairbanks or by transforming its latent power into electric power and transmitting it to places where it is needed, but uncertainty as to the Government's policy with regard to the coal lands has delayed this enterprise. Not enough water is available for use as a direct source of power at the mines and mills, and the

projects that have been proposed to utilize the more distant supplies required so large an investment and presented so many difficulties that they have been abandoned. With increased transportation facilities some decrease in charges for wood and gasoline may be expected, but decided reduction in the cost of power probably depends on the development of the known coal resources.

MISCELLANEOUS SUPPLIES.

Increased development requires a more elaborate surface and underground equipment, and at those mines which are far from their mills cheap methods of intercommunication must be devised. All these matters demand careful consideration and can be most economically and satisfactorily determined through detailed examination by competent authorities. Ordinarily the looser methods practiced in many placer camps are not permissible in lode mining, and operators should obtain expert advice before undertaking the purchase of expensive machinery and similar equipment or laying out a system for future underground development.

In the shallower parts of the deposits visited little or no timber is now used. The walls stand well even down to 300 feet below the surface, and the few timbers seen were used more for lagging than for carrying weight. So little strength is required that most of the timber is merely 16-foot cordwood, much of which has been charred by forest fires. That not much support is necessary underground is fortunate, for a set of round pole timber (three pieces) costs $3 and a square set about $6, and very little good material for mine timbers can be found near at hand. The amount of timber used when more extensive openings are made underground will be much greater in proportion to the size of the openings than at present, and increasing difficulty and expense in getting a suitable supply should be expected.

PLACER MINING IN THE YUKON-TANANA REGION.

By C. E. Ellsworth and R. W. Davenport.

SOURCES OF DATA.

The aim of this report is to gather together in brief form all available information of importance concerning placer mining in the Yukon-Tanana region in 1912. The writer visited the Fairbanks, Circle, Fortymile, Eagle, and Seventymile districts to study the water supply and incidentally gathered some information concerning the mining. Many of the data, however, were obtained from statements of operators and local press reports received at the Survey office in Washington.

FAIRBANKS DISTRICT.

GENERAL CONDITIONS.

The value of the production from gold placers in the Fairbanks district in 1912 was $4,150,000. No changes or improvements of importance in methods of recovering the gold were introduced. The production has been kept up largely by new discoveries and the widening of the known gold-bearing areas on creeks that have yielded some gold during past years.

The principal producing streams, arranged nearly in value of gold output, are as follows: Goldstream and Engineer creeks, Cleary Creek and Chatanika Flats, Dome Creek, and Chatanika Flats, Eva, Ester, Pedro, Fairbanks, Vault, and Little Eldorado creeks.

Labor conditions were fairly satisfactory and the usual wages of $5 a day and board prevailed. Many men left for other camps, particularly Ruby, and others shifted their efforts from placer to lode mining. New arrivals, however, supplied the demand fairly well and the number of men engaged in placer operations did not vary far from that of 1911. It is estimated that from 130 to 140 plants were in operation for either a whole or a part of the year and that the number of men employed ranged from about 900 in the winter to perhaps 1,500 in the summer.

The water supply was better in 1912 than in 1910 or 1911 and satisfied the needs of the miners as well as could be expected in a country of very low rainfall and rapid run-off.

The dredge on Fairbanks Creek is the only one yet installed in the district, but rumors are current that other dredges will be brought in, and options have been taken on ground deemed suitable for such methods. Hydraulic mining has not been undertaken except on a very small scale and probably never will be found adapted to the conditions in this district.

Recent press reports state that a hydroelectric power plant located on Chatanika River near Pilot Creek is contemplated. The plans involve the diversion of the water from the river and the construction of 11 miles of ditch.

CHATANIKA RIVER BASIN.

Dome Creek.—From claim "No. 7 above" to "No. 6 below" on Dome Creek ten to twelve outfits employing about a hundred men were mining most of the summer of 1912. No data are at hand to show the amount of winter work accomplished, but it was probably less than that done in the summer. The production from that part of the creek for 1912 was probably equal to or greater than that of 1911.

In the Chatanika Flats near Olness, near the mouth of Dome Creek, about 250 men were employed at six or seven plants. The Niggerhead Association, which comprises the most important group of claims in that locality, had three large plants in operation and was perhaps the scene of the most extensive mining in the Fairbanks district in 1912. Considerable work was done on the Recorder Association claim and on the Shakespeare claim. On the Christmas Association claim good pay was reported at a depth of 177 feet.

Cleary Creek.—The fact that Cleary Creek continues to be one of the most productive creeks in the camp is due almost entirely to the extensive deposits of auriferous gravels that have been found near its mouth in the Chatanika Flats.

Nine to twelve outfits, employing a total of twenty-five to fifty men, were at work in 1912 from claim "No. 10 above" to claim "No. 10 below." A large number of these men were either rewashing the tailings from the old dumps or were hoisting the pillars and unworked portions that had been left in the mines during the more prosperous days of the camp.

Below claim "No. 10 below" about fifteen outfits were at work, employing perhaps 70 men in the winter and 275 in the summer. Much of the ground has been of rather low grade and very little of it has earned a profit unless worked under the most careful management. Early in the winter of 1912 a new line of pay gravel was found on the right bank of Cleary Creek opposite claim "No. 16 below" and was located by prospecting shafts for a considerable distance up and down the valley. Several plants of large capacity

were hurriedly installed. The ground, however, did not prove as rich or as widely extended as at first expected and several of the plants were unable to pay expenses, only three or four plants being worked continuously throughout the summer. The gold is said to be coarse and different in appearance from any previously found on the creek.

On Wolf Creek, a tributary of Cleary Creek, two men were mining in the winter and eight to ten in the summer. Very good returns are reported to have been obtained. On Chatham Creek, another tributary of Cleary, no placer mining was done in 1912.

Vault Creek.—In the summer of 1912 several large outfits were mining on Vault Creek, employing a maximum of about a hundred men. The principal group of claims was the Alabama. Other groups of importance were the Isabella, Oregon, Homestead, and Hard Luck.

On Treasure Creek, a tributary of Vault, four or five small outfits were working; and on Wildcat Creek, a small tributary of Treasure, two small plants were working.

Little Eldorado Creek.—Little Eldorado Creek has never satisfied the expectation of its earlier prospectors and promotors. In 1912 mining was being done at three or four different points, and considerable prospecting was in progress, the men employed varying from thirty in winter to sixty in summer. The principal claim was "No. 6 above." Bedrock lies at a depth of about 85 feet. It is said that sufficient pay gravel has been located to furnish work for one plant for several years.

Homestake Creek.—The hydraulic plant on Homestake Creek was not operated at any time during 1912. One man was mining by hand methods most of the summer.

GOLDSTREAM BASIN.

Goldstream Creek.—Although the production from Goldstream for 1912 will probably not equal that for 1911 it will put the creek near the head of the list. The left-limit bench claim of "No. 9 below," owned by the M. B. Mining Co., has proved to be one of the richest claims in the camp. No mining was done below claim "No. 21 below," but prospecting has shown a considerable body of gravel farther down the valley with an average value of about 50 cents per square foot, not enough to pay for working at present costs. Two plants are now working on claim "No. 1 below," which is and has been for several seasons one the largest producers on the creek. Steam scrapers were used on claim "No. 6 below," the lowest claim on the creek that was worked by open cut. Steam scrapers were also used on "Nos. 4 and 5 below." The outlook for several more prosperous seasons on the creek is particularly good, as many of the

operators have sufficient pay gravel in sight to last one or more seasons and prospecting is continually revealing new deposits.

The number of outfits mining on the creek varied greatly during the year, ranging from about fifteen with 150 men in the winter to perhaps thirty with 250 men in the summer.

On First Chance Creek, a small stream entering Goldstream from the left near "No. 5 below," two or three small outfits were mining most of the year. On "No. 1 below" five or six men were employed on ground about 35 feet deep.

Pedro Creek.—The gravels of Pedro Creek are shallow, varying from 12 to 15 feet, and have been mined chiefly by open-cut methods. During the winter of 1911–12 about fifteen men were drifting on four claims. Summer mining was carried on more extensively, probably 75 to 125 men being employed in the open cuts. Several outfits were using bottomless scrapers. Other plants were using steam hoists, the dirt being conveyed to the buckets in wheelbarrows. A few men were working with a windlass. On Twin Creek fifteen to twenty men were employed in operating a Bagley bottomless scraper.

Gilmore Creek.—On Gilmore Creek four or five claims were mined by 12 to 15 men. The prevailing method of handling the gravel in the summer was by conveying it in wheelbarrows to a bucket which was raised by a steam hoist to the sluice boxes.

Engineer Creek.—In 1911 Engineer Creek was one of the busiest creeks in the district, several outfits on it operating on a very large scale. The year 1912, however, has seen a rapid decrease and the consensus of opinion of those personally familiar with the conditions is that the pay streak is about worked out. During the winter of 1911–12 two parties were at work on the Owl Association and one each on Discovery claim, "No. 1 above," and the Wild Goose Association claim. About thirty-five men were employed. The summer of 1912 was still less encouraging. One small outfit was mining on Discovery, which was the most promising claim; one party of four or five men was mining on the upper end of the Owl Association; and several men were resluicing tailings on the Wild Goose Association claim. Scrapers were used to raise the gravel to the sluice boxes.

CHENA RIVER BASIN.

LITTLE CHENA RIVER BASIN.

Fairbanks Creek.—Fairbanks Creek is the only stream in the Chena River basin on which gold in any considerable quantity has been found. It has been one of the most consistent producers of any of the creeks in the Fairbanks district. To the traveler passing through the valley during the past season there were very few signs of mining

being done. Nevertheless, the value of the production for 1912 will amount to over $200,000. In the winter thirty-five outfits were at work, employing a total of about 135 men. In the spring, as soon as sluicing water became available and seasonal conditions would permit open-cut mining, the number of outfits decreased to about twenty-five, and the number of men employed increased to approximately 225. Mining extended from claim "No. 17 above" to "No. 10 below."

The dredge which was constructed on claim "No. 8 above" in 1911 commenced operations about June 1. Its workings were watched with particular interest by the mining men of the camp, as it was the first dredge to be installed in the Fairbanks district and its success or failure would likely have considerable influence on future dredging in this section. During the early part of the season many factors contributed to its ill success. Later on, operating conditions improved, and as a whole the season's work is believed to have been very satisfactory. It is expected that it will not be necessary to suspend work for the winter until about December 1. At the time of the writer's visit, August 7, 1912, the dredge had moved a total distance of 1,320 feet upstream, through an average depth of 20 feet and a width of 100 to 110 feet. It is operated on two shifts of 11½ hours by five men (pilot, engineer, fireman, grizzlyman, and dump-boxman) per shift. Some difficulty was experienced during the early part of the season by frozen ground, and steam points were used to thaw the muck and gravel so that it might be easily handled by the buckets. A Keystone drill was used to determine approximately the boundary lines of the pay streak. The cost of wood for fuel has become so great that the installation of oil burners and the obtaining of crude oil from California is contemplated.

The extent of the known gold-bearing area in this valley has been considerably increased during the past year. In March, 1912, pay gravel was first located on the right limit of the creek, being found on the first tier bench on claim "No. 1 below." The ground is about 35 feet deep and averages $1.25 to $1.50 per square foot. Tunneling showed a pay streak at least 100 feet in width. During the latter part of July some exceptionally rich ground was found on claim "No. 3 below," and is thought to be an extension of the old Fairbanks Creek pay streak. Pans of gravel of $10 and upward in value were frequently found, and later developments proved that the area containing these high values was of considerable extent. A third discovery was made in August on the left limit bench, near the mouth of Walnut Creek, on claim "No. 2 below." The ground is said to carry values of $2 to $2.50 per square foot. On claim No. 3 of Walnut Creek, a small tributary of Fairbanks Creek, two men were working in open

cuts most of the summer. Some mining was also done on Alder Creek, another small tributary of Fairbanks.

A steam scraper was used on claim "No. 1 above" most of the summer. A self-dump hoisting plant was used in an open cut on claim "No. 3 above," the gravel being conveyed to the bucket by wheelbarrows. About twenty men were employed. Options have been obtained on several claims below those controlled by the Alaska Exploration Co., and it is rumored that an attempt will be made to organize a company and install a dredge on the property.

Fish Creek and tributaries.—Fish Creek has failed to come up to expectations during the past two years. Prospecting has proved the extension of large bodies of low-grade ground, but comparatively little of it has been found rich enough to pay for working by the methods employed. Five to ten outfits employing thirty to forty men were mining on the creek during the year.

On Pearl and Last Chance creeks, tributaries of Fish Creek, some open-cut mining was done during the summer months.

Smallwood Creek.—Several claims were mined on Smallwood Creek, where a deposit richer than ordinary is said to have been found during the year.

SOUTH FORK OF CHENA RIVER BASIN.

On South Fork of Chena River considerable prospecting has been done. On Beaver Creek, an east branch of South Fork, ground averaging about $1 a square foot is said to have been found early in the winter of 1911–12. Several windlass dumps were taken out.

MIDDLE FORK OF CHENA RIVER BASIN.

Middle Fork of Chena River and some of its branches have been known for several years to carry coarse gold, but the only locality at which the gravels are known to be rich enough to warrant mining is along the river bars above Shamrock Creek. Here considerable development work has been done, timber dams being built to divert the river and drain its channel, and considerable coarse gold has been recovered. The extreme high water of June, 1912, washed out the greater part of a dam nearly completed, and the remainder of the season was devoted to repairs and to excavating a larger side channel. Several men were prospecting on the Middle Fork and its tributaries during the winter of 1911–12, and a lesser number were similarly employed during the summer.

CRIPPLE CREEK BASIN.

No mining was done on main Cripple Creek during 1912, although good prospects are said to have been found on the Golden Champion Association claim.

Ester Creek.—On claim "No. 8 below," on Ester Creek, about fifty men were employed most of the year. On "No. 3 below," about the same number were engaged during the summer, but only ten to fifteen were employed in the winter. One small outfit was mining on Discovery claim. On the right limit bench of Discovery two large plants were working throughout the year. A large plant worked on "No. 1 above" in the summer and another on "No. 2 above" in the winter. Five or six men were mining on "No. 4 above" during both summer and winter. The total number of men mining on the creek varied from about 150 in the winter to 225 in the summer.

Operations were somewhat curtailed, especially on the benches, during part of the summer, because of lack of sluicing water.

One outfit on Discovery bench began sluicing in the latter part of March, a date earlier than any known in the history of the camp, where sluicing with water from surface run-off has never before been accomplished previous to April 1.

Although several claims that have been productive in the past are worked out, new ones have been located, and the output for 1912, which is estimated at approximately $300,000, does not show much decrease from previous years.

Eva Creek.—Eva Creek has shown the most rapid increase in production of all the streams in the district, jumping from a few thousand dollars in 1911 to about half a million in 1912. Most of the prospecting was done with a churn drill. Exceptionally rich ground was found on the Daly Bench and Happy Home Association claims. In the winter of 1912 three plants, employing from eighty to ninety men, were in operation on the creek. The following July two plants, employing about forty men, were in operation. It is understood that later in the season the operations were more extensive.

Ready Bullion Creek.—One plant, employing about fifty men, was in operation on Ready Bullion Creek during the winter of 1911–12. No mining was done in the following summer because of the particularly unfavorable location of the mines for obtaining sluicing water.

BEAVER CREEK BASIN.

Some prospecting was done in 1912 on various creeks in the Beaver Creek basin and pay dirt is reported to have been found on several of them.

The most encouraging results were obtained on the right limit of Nome Creek a short distance above the mouth of Ophir Creek, where several lines of holes were sunk to bedrock. Considerable open-cut work was done on the rim of the bench by using rain water caught on the hillside. More prospecting and development work is contemplated for 1913 than has previously been accomplished. The gold is

mostly coarse, and according to the judgment of the prospectors is "pay-streak gold."

On claim "No. 18 above association group" on Nome Creek two men were engaged during the spring and early summer in building diversion dams and ditches to drain the creek channel at spots where pay dirt was thought to be located or where it was desired to do further prospecting. Later in the season sluice boxes were set up and some gravel was washed. The ground averaged about 12 feet in depth.

Three or four men were working with a windlass on Discovery claim of Ophir Creek at times during the year. Returns are said to have been fair.

CIRCLE PRECINCT.

GENERAL CONDITIONS.

The value of the gold production from the Circle district in 1912 is estimated at $325,000. It was recovered by methods similar to those employed in 1911, with the exception of that contributed by a dredge on Mastodon Creek. The water supply was somewhat better than in 1911, but during July and part of August it was insufficient for continuous hydraulicking. In the winter of 1911–12 between twenty-five and thirty small outfits made up of about seventy-five men were engaged in mining. The following summer the number of men employed varied from 125 to 175, depending chiefly on the water supply, although, during periods when the water supply was sufficient, there was at times a shortage of men, particularly for the first few days immediately following a protracted period of dry weather. The open season of 1912 began about two weeks earlier than usual, but during June the weather was so cold and cloudy that the muck and gravel in the open cuts thawed very slowly and progress was considerably impeded. The Alaska Road Commission continued toward Miller House the construction of the wagon road previously completed as far as Central House. Just what progress was made is not known, but it was expected that by the end of the summer the road would be in such shape that wagons could be comfortably taken as far as Miller House.

BIRCH CREEK BASIN.

Mastodon Creek.—Radical changes in mining methods have taken place on Mastodon Creek during the past two years. Hydraulicking and dredging have been largely substituted for the hand methods so long in vogue.

The first dredge in Yukon Territory was constructed on Stewart River in 1898. In 1901 it was moved to Bonanza Creek, a tributary of Klondike River. In the fall of 1912 the same dredge was floated

down the Yukon to Circle, where it was dismantled and during the winter hauled on sleds to Mastodon Creek. It was reconstructed on claim "No. 10 above" and commenced operations on May 28, 1912. It is of the Risdon type with buckets of 3½ cubic feet capacity. The hull is 32 by 70 feet. About twenty men were employed on and in connection with the machine. The greatest difficulty met by it was frozen ground. Boilers were not available for thawing in advance of the dredge, and when frozen ground was encountered it was necessary to stop the buckets and use the dredge boilers to furnish steam for the thawing points. Notwithstanding such serious delays fair progress was made and the operators expressed satisfaction with the results. Another season ample facilities for thawing will be provided and a particularly prosperous season is looked forward to. The wood used for fuel was obtained from the Porcupine Creek valley near Mammoth Creek at a cost of about $15 a cord.

The hydraulic plant on claim "No. 6 below" did very well during May and June, during which about twenty men were employed. For the remainder of the season the water supply was not sufficient to furnish a continuous working head and long delays resulted.

Probably the hydraulic plant on claims "Nos. 19 and 20 above" had the most successful season of any of the camp. The first cut of the season, measuring about 12,000 yards, was taken out in May and June under favorable conditions at a cost of 13½ cents a cubic yard, and the average cost for the season was estimated at somewhat less than 25 cents a cubic yard. From eight to sixteen men were employed. A working head of about 100 feet was available at the nozzle. About 1,000 feet of 14-inch and 1,500 feet of 10 and 8 inch pipe, four gates, two No. 1 and one No. 2 giants, and sluice boxes, 30 inches wide with block riffles, were used. One box was equipped with patent riffles and undercurrent to save the fine gold. A No. 2 giant was used to stack the tailings when there was sufficient water, and at other times a 1-yard bottomless scraper was used. The capacity of the plant under average working conditions was said to be about 400 cubic yards a day.

A. P. Clark plans to install a small hydraulic plant near the head of the creek in the spring of 1913. The equipment for the plant was received at Circle in the fall of 1912.

Only ten to fifteen men were mining on the creek during the winter and about seventy during the summer.

Deadwood and Switch creeks.—Mining was conducted on Deadwood Creek during 1912 by the usual hand methods and to about the same extent as in previous years. The number of men engaged in mining varied from twenty-five to thirty-five, divided into fifteen to twenty different parties.

On Switch Creek, a tributary of Deadwood, five outfits employing ten to twelve men were engaged in mining throughout the year. Some hydraulicking was done on the left-limit bench not far above the mouth of the creek. The water was diverted from the creek above by a short ditch and pressure at the nozzle was obtained by a canvas hose.

Mammoth Creek.—The hydraulic plant located on Mammoth Creek above the mouth of Miller Creek had a rather unfavorable season. A belt of relatively low rainfall extended across the headwaters of Porcupine and Bonanza creeks, from which the water supply for the plant is obtained. Delays due to other causes occurred at times of good water supply, when any loss of time was of the most serious consequence. About twenty men were employed by the owners, several of whom were engaged in the maintenance of the ditch. Near the pressure box the ditch was enlarged so that by closing the head gates when the natural flow was insufficient for hydraulicking, a small amount of storage was obtained. The giants could then be operated under full pressure for a period of half an hour or more, depending on the number and size of nozzles used. The time required to fill the reservoir, of course, depended on the water supply at the ditch intake and on the seepage and other losses incurred in transit.

This system permits the operation of the plant for a short time at short intervals, when otherwise it would be necessary to close down entirely. Apparently under proper management the men could ordinarily be engaged in dead work while the reservoir was filling, and the plant could be run on nearly as efficient a basis as when operating continuously.

Eagle Creek.—The hydraulic plant on Eagle Creek commenced work on May 13, about two weeks earlier than in any previous year. The water supply was somewhat better than ordinary. It is understood that the results of the summer's work were satisfactory. An average of about ten men were employed in connection with the plant. Some mining was done by hand methods by one man on the creek about a mile below the hydraulic plant. Another man was engaged in open-cut mining by ground sluicing and pick and shovel on Mastodon Fork of Eagle Creek.

Independence Creek.—On Independence Creek, on claims "Nos. 8 and 9 above," ten to twenty men were employed in conveying the auriferous material from an open cut in wheelbarrows to the buckets of a steam plant, which hoisted it to the sluice boxes. A shortage of men during part of the summer and insufficient sluicing water for a considerable period combined to produce a rather unsatisfactory season. Several other men were mining along the creek at times during the summer.

Other creeks.—One man was engaged in prospecting the right bench of Birch Creek about a mile below Twelvemile Creek. He constructed a small ditch to a near-by gulch, from which he obtained sluicing water, and made a large open prospecting cut for several hundred feet across the bench. Sluice boxes, canvas hose, and nozzle were used, but gold in paying quantities was not found.

Along Birch Creek and in the vicinity of Buckley Bar four or five men were mining during the summer. Some mining was also done on Bottom Dollar, Half Dollar, and Greenhorn creeks.

On Portage Creek, about 4 miles above Medicine Lake, two men constructed a large dam across the valley and did considerable ground sluicing by means of an automatic dump gate during the latter part of the summer. The creek at and above the claim cuts through a granite formation, and the accumulation of heavy bowlders makes mining very difficult and expensive.

Rich placers were found on Lawson Creek, but sufficient work was not done to prove their extent. A quartz vein that crosses the valley just above this discovery is believed to be the source of the placer gold.

YUKON BASIN.

From seven to fourteen men were engaged in mining on Woodchopper Creek and tributaries during 1912. The principal branches of Woodchopper Creek on which gold has been found are Mineral, Alice, and Iron creeks.

On Coal Creek, including its tributaries Boulder and Rose creeks, ten to twenty men were either prospecting or mining. A few men, mainly prospectors, were working on Sams Creek, and some were working on Fourth-of-July Creek.

FORTYMILE DISTRICT.

GENERAL CONDITIONS.

For 1912 the estimated gold production of the Fortymile district is $230,000; for 1910 and 1911 it was $200,000 each year. The increase is attributed to the better water supply of 1912. The winter of 1911–12 was exceptional in its high mean temperature and its small precipitation. Consequently at the coming of warm weather in April and May the melting snow and ice did not cause the usual high run-off. No precipitation of any amount occurred before the latter part of May, and until then the creeks were abnormally low. At that time, however, a period of well-distributed precipitation began, and for the greater part of the summer the water supply was excellently suited to the requirements of the miners on the small creeks.

The chief methods of mining in the district are by drifting, open cut, and dredging, the greatest part of the production being by the last-named method. Except on Chicken and Wade creeks very little actual mining is done in winter, though considerable dead work is accomplished. No extensive hydraulic plants are in operation in the district, but it is believed that the construction of such is being seriously considered and that ultimately this method will be employed to a much wider extent.

The success of two or three miners on the benches of the lower Fortymile and the prospects that have been found there promise considerable gold production from a source which until recently had been considered unpromising. Further prospecting and careful study of the available water supply may show the feasibility of using hydraulic methods extensively in mining these benches.

Three dredges were in operation in the Fortymile basin on the American side of the boundary and one on the Canadian side. It is believed that they experienced a prosperous season. The most important change during 1912 was the dismantling of the Walker Fork dredge at the end of the season for removal over the divide to Miller Creek, in Canadian territory.

No further developments of importance have taken place in regard to the gold-bearing quartz on Mosquito Fork or the copper ore deposits at the headwaters of its tributary, Kechumstuk Creek. A little excitement was caused in August by the discovery of scattered copper ore in the drainage basin of Middle Fork, over the divide and about 8 miles from the copper deposit at the head of Kechumstuk Creek. Attempts were made to locate the lode at the head of Kechumstuk Creek, but it is believed the results were not very encouraging. The appearance of copper ore in these two places indicates that it is rather widely distributed. The remoteness of the locality from transportation facilities presents a difficulty which would prohibit profitable development, even if it were otherwise feasible.

The Fortymile district is likely to continue for many years as a fair gold producer. With the entrance of capital, the construction of good roads, and improved mining methods its importance will probably increase.

SOUTH FORK OF FORTYMILE RIVER BASIN.

Ingle Creek.—On Ingle Creek five men worked throughout the year with good success. In the winter gravel dumps were taken out by drifting and in the spring were shoveled into the sluice boxes. In the summer considerable work was accomplished by means of open-cut methods.

Chicken Creek and tributaries.—Chicken Creek has a comparatively small drainage area and, in addition, certain natural features which

make it a poor conserver of water supply. Consequently its gold production is very dependent on weather conditions. During the summer of 1912 these conditions were more favorable than for several years past, and the miners were able to operate the greater part of the time. The Chicken Creek gravels are rich in gold and when there is sufficient water for sluicing very good results are obtained. About twenty-five men were working in this locality throughout the season—by drifts in the winter and mostly by open cuts in the summer.

Denison Fork.—A ditch about 2 miles in length was completed to divert the water of Deep Creek and other intercepted drainage to benches on the right limit of Denison Fork about one-third mile above its mouth. The ditch was completed in midsummer, but the owner was obliged to leave the work for the rest of the season. It is anticipated that the drainage which may be collected by this ditch will be sufficient for sluicing only during the early part of the season when the snow and ice are melting and for short periods after summer rains.

Prospecting was done about 40 miles above the mouth of South Fork of Denison Fork by one man, who reports placer gold to be very generally distributed and to be fine in character, though colors from 10 cents to 30 cents in value have been found. The gold near the mouth of Denison Fork is very fine. South Fork is so remote that it would be difficult to arouse much enthusiasm for any mine there that was not exceptionally good.

Walker Fork.—The Walker Fork dredge had a very good season. It worked up Walker Fork to the mouth of Poker Creek and a few hundred feet up the latter stream. It was dismantled about September 1 for removal over the divide to Miller Creek, in Canadian territory, where it will be operated on the claims of the North American Transportation Co. A cloudburst in late July caused considerable trouble at the dredge by filling the pond in which the dredge floated with gravel, which had to be scraped out before operations could be resumed. About 4 miles of claims on Walker Fork near the mouth of Cherry Creek, which it had been expected this dredge would work, remains untouched and will probably be mined by other methods.

Six men were working on Davis and Poker creeks throughout the season by open-cut methods. A prosperous season was reported.

Wade Creek.—On Wade Creek the results for the season were fairly satisfactory. Twenty-five or thirty men were engaged in mining on this creek during the winter and summer. A number left after the spring clean-up, but their places were filled by newcomers. In July operations were at a standstill because of low water, but for most of the summer the supply was ample. Wade Creek gold is characteristically large and coarse, and one of the interesting finds of the summer was a nugget weighing about 17 ounces. No new developments

were undertaken on this creek, though there were rumors of projects which may materialize in the future.

Napoleon Creek.—Four men were at work on Napoleon Creek all summer, one of them prospecting the benches about one-half mile above the mouth and the others engaged in open-cut mining near the mouth. Much work was accomplished, considerable ground being stripped preparatory to shoveling into the sluice boxes during the coming season.

Franklin Creek.—Six men were working on Franklin Creek most of the season. Mining on this creek was begun about 1885, antedating most of the Alaskan placer discoveries by several years, but it still continues profitable when the water supply is favorable.

Buckskin Creek.—One man worked on Forty-five Pass, a tributary of Buckskin Creek, for the entire season with very good success.

South Fork of Fortymile River.—The Atwater dredge had a successful season, excavating an area of about 4,000 feet on South Fork of Fortymile near the mouth of Buckskin Creek. The extreme high water in June necessitated the cessation of operations for a short time. The dredge draws 5½ feet and requires at least 7 feet of water to do effective work, and shallow gravel on the bedrock at some points and reefs at others compelled the building of many dams to give the required depth.

The bars of South Fork have been repeatedly worked and yielded very little gold to the dredge except where the gravels were under water and could not be reached by crude methods. The dredge will probably work seven or eight miles of river bed above its present location and will probably take as many years to do it. During the coming season it will probably be located between Buckskin and Franklin creeks.

CANYON CREEK BASIN.

Canyon Creek.—Two men were working at the head of Canyon Creek most of the season and reported good success. Below the mouth of Squaw Gulch some work was done in 1910 and 1911, but nothing was accomplished in 1912.

Squaw Gulch.—Squaw Gulch was the scene of considerable activity throughout the season, about eighteen men being engaged in mining. At the head of the creek, near the mouth of Kalamazoo, three men worked at ground stripping, but were handicapped by lack of water from the small tributary watershed and stopped work in early August. A little mining was done on a bench above Baby Creek by utilizing the early run-off from the melting snow. On Squaw Gulch, just above the mouth of Baby Creek, two men were drifting. They reported good results and will probably continue work through the winter.

On a claim just below Baby Creek an outfit of six men worked for the entire season, using a very efficient method. A bottomless steam scraper of three-fourths yard capacity, made of manganese steel, and a boiler of 40 horsepower were used. The muck, which was variable in depth, was sluiced off and then 2 to 6 feet of gravel were thawed with steam points and scraped off. The last 1½ feet of the gravel next to the bedrock was scraped up an incline to a platform about 20 feet high and there dumped into the sluice boxes. According to the statement of the manager 200 yards of wet gravel or 250 yards of dry could be handled in a day, with a consumption of about one cord of wood. The scraper was said to have cleaned the bedrock very effectively, but this was probably due to the comparative evenness of the latter. Had it been uneven the cost would undoubtedly have been much greater. Much preliminary work had to be done, but nevertheless about 80 box lengths, or 11,520 square feet, of bedrock were cleaned. The results are believed to have been satisfactory.

On claim "No. 1 above" two men worked the entire summer, using a dump gate and ordinary open-cut methods.

MIDDLE AND NORTH FORK OF FORTYMILE BASIN.

Three men worked most of the summer on Confederate and Montana creeks, tributaries of Hutchinson Creek. In August several men were prospecting on Fish Creek, which enters Middle Fork, but aside from this no other work is known to have been done in the North Fork drainage basin in 1912.

LOWER FORTYMILE RIVER BASIN.

Minor creeks.—Very little progress was made on Dome, Flat, and Twin creeks, but considerable work is in prospect on Dome Creek for the coming season.

Fortymile bars.—The number of men engaged in mining on the bars of the lower Fortymile was greater than it has been in recent years, it being estimated that twenty-five or thirty men were working with rockers the whole or a part of the season. Green Island and Bonanza Bar were the points of the greatest activity. The stage of water was too high for the best results, and as much of the gravel had been worked repeatedly it is doubtful if very great quantities of gold were recovered.

Fortymile benches.—Bench mining was in operation or in prospect at two places on Bonanza Bar.

About 1½ miles above the mouth of Canyon Creek a man made a large excavation and was able to take out some gold, but the available water supply is poor and operations are very uncertain. Near the mouth of Canyon Creek a man spent the summer on a ditch which

will divert water about 2 miles above the mouth of Canyon Creek and will carry it to a bench on Fortymile River about three-fourths of a mile above Canyon Creek. The ditch will be about 2½ miles in length and is planned to furnish 3 or 4 second-feet at the bench with a head of about 75 feet on bedrock.

On Discovery Bar, about half a mile above the mouth of Discovery Creek, one man was mining on a bench, with results that were very encouraging while water was available. The water, however, was obtained from Discovery Creek, which is small and unreliable, and consequently much of the season was lost. A new ditch is contemplated which will utilize a storage reservoir and furnish a greater head for sluicing.

On Claghorn Bar, about 1½ miles above Moose Creek, a man was working throughout the summer and was said to have obtained good results. A 3-mile ditch, about half of which is flume, diverts water from Elmer Creek, a tributary of Moose Creek rising in American territory, and carries it up the valley to this bar. The capacity of the ditch is at present not much greater than a good sluice head.

The gold in these benches is fine and flaky. Undoubtedly its reconcentration has supplied the river bars.

The Canadian Securities Co. (Ltd.) operated two dredges on the lower Fortymile. A large dredge well adapted to the heavy work on this river worked in Canadian territory and is said to have had a favorable season. The second dredge was located on the American side of the boundary about half a mile below Moose Creek. It is small and light and handles the heavy bowlders with considerable difficulty, frequent stops being necessary to remove the large stones from the buckets. This dredge was held up for repairs for probably half of the summer.

SEVENTYMILE DISTRICT.

GENERAL CONDITIONS.

The combined output of gold in the Seventymile and Eagle districts for 1912 is estimated at $20,000, somewhat more than in recent years.

The miners in the Seventymile basin had abundant water throughout the summer. More men were at work than in 1911, and more work was accomplished, but in the main results were rather discouraging. There is much low-grade placer ground in this district, but little gold seems recoverable at a profit by the methods in common use by the small operator.

In the early summer men appeared in Eagle with a proposition for putting a dredge on the lower Seventymile, but it is not known that they were able to arrange any definite plan. The future success of

mining in this district depends on further prospecting and on the adoption of different mining methods, for which greater capital will undoubtedly be necessary.

SEVENTYMILE RIVER BASIN.

Flume Creek.—In March some prospecting was done on Flume Creek about 3 miles above its mouth. About 200 feet of holes were sunk in the creek and in the high bench on the left, but no good prospects were found. The only valuable placers found on this creek thus far are near its mouth and on Arctic Creek, a tributary from the left. Representation work was done on the claim at the mouth of the creek, but conditions were unfavorable for the recovery of much gold.

Alder Creek.—Four men worked on Alder Creek for practically the whole season. The gold is coarse, and during the summer a number of nuggets valued at from $3 to $8 and one of $25 were found. Some of the gold is rough and other specimens are well worn. The deposits seem to be rather irregularly distributed.

Barney Creek.—Two men worked on Barney Creek and stripped a considerable area of bedrock, but did not obtain very encouraging results. The clay in the gravel and the deep muck caused much difficulty.

Washington Creek.—Two men used a dump gate to do ground-sluicing at the mouth of Washington Creek and had a fairly profitable season. Three men were prospecting on the upper portion of the creek during the early part of the summer. No placers of importance were reported.

Sonickson Creek.—The mining operations at the falls on Seventymile River for which the waters from Sonickson Creek have been used were vigorously continued until August 1, when it was decided that the natural conditions in the bench which was being worked were so inimical to success that it would be wise to discontinue operations. The principal difficulties were probably the great depth of overburden and the fact that the bedrock could not be drained with facility.

Crooked Creek.—Five men worked on Crooked Creek for the whole season and reported the results to be favorable. One man prospected in the vicinity of the mouth of Eldorado Creek.

Fox Creek.—Four men worked on Fox Creek. Two of them drifted on Lucky Gulch about half a mile above the mouth, and the other two groundsluiced with a dump gate and shoveled in over a considerable area below the mouth of Lucky Gulch. No rich gravels were found.

Other creeks.—One man spent the summer trying to mine in the bench a short distance above the mouth of Pleasant Creek. The water supply is obtained from the head of Washington Creek by a

ditch about 2½ miles in length which gave constant trouble because of the thawing of the ground over which it was built. Attempts at mining on this bench seem to have been discouraged for the present.

Mining was done on Canyon and Broken Neck creeks, two men being at work on each. On Nugget Creek three men took out a dump during the latter part of the winter and two or three men were at work on the creek most of the summer.

On Curtis Bar operations were continued by one man throughout the season, the favorable water supply affording an opportunity for doing more work than in any recent year.

At three different points on the Seventymile men were engaged in "sniping." Results are not believed to have been very encouraging.

EAGLE DISTRICT.

A prosperous season was experienced on American Creek and Discovery Fork. The good water supply afforded an opportunity for doing a great deal of work and the ground was rich enough to make the results profitable. On American Creek two claims were being worked and the combined amount of ground stripped and shoveled in was about 17,000 square feet. At claim No. 8 an $80 nugget was found. On Discovery Fork about 11,000 square feet were sluiced off and shoveled into sluice boxes. About fifteen men were engaged in mining in this district throughout the season.

HOT SPRINGS DISTRICT.

Incomplete reports from the Hot Springs district indicate that mining operations during 1912 were confined mainly to the Patterson and American creek basins.

AMERICAN CREEK BASIN.

On American Creek, which is a small stream about 5 miles long entering Fish Lake from the northeast, gold prospects were found over a considerable area in 1911. Recent reports show that active mining is being carried on by ten to fifteen different outfits and that some very rich ground has been found. The Wild Goose Association claim will probably be the principal producer in 1912. It is reported that three pans of material taken at random from a particularly rich spot on this claim yielded about $100. A nugget valued at $1.25 was found and as high as $2 per square foot of bedrock has been reported. Supplies are shipped in summer by motor boat from Tanana River to points within 3 or 4 miles of the mines. Some machinery has already been installed, but at present most of the gravel is hoisted by hand. The average depth to bedrock is said to be about 14 feet and in many places it is only 10 to 12 feet. The claims are situated so near the head of the creek that water is not available for ground sluicing, and open-cut methods have not been employed.

PATTERSON CREEK BASIN.

In the Patterson Creek basin the gold production for 1912 was probably less than in 1911, but prospecting during 1912 has increased the known gold-bearing area to an extent very encouraging to those interested in the future of the camp. Very little information regarding the Sullivan Creek mines has been received since early in 1912, at which time some work was being done on the Midnight Sun Association claim and on the Junction fraction just below. Two outfits were working on the Abe Lincoln claim; one had found good prospects in a 50-foot shaft at the upper end of the claim, and the other at the lower end had blocked out 100,000 square feet of ground, with an estimated value of $2 per square foot. On the right limit bench, opposite Discovery, pay gravel had been recovered from three shafts and plans were under way for work on a large scale. Rich ground is reported to have been found with a Keystone drill on the Hartner claim below Discovery. Considerable work was done on the claim next below the Hartner claim, also on the McVicar, Snyder, and Marshall claims. Open-cut mining was continued on Tofty Gulch. Considerable mining was done on Miller Creek and some on Cache Creek. Prospecting on Coonie Creek shows a considerable area of very low grade ground with the gold rather irregularly distributed.

Placer tin in larger quantities than formerly has been found in the Sullivan and Cache creek mines, and considerable time and money has been spent near the headwaters of these streams in the effort to locate its source. Conflicting reports as to the results are at hand.

BAKER CREEK BASIN.

In the older section of the Hot Springs district, which includes streams tributary to Baker Creek the principal producers were Pioneer, Thanksgiving, and Eureka creeks. At the What Cheer Bar mines about the usual amount of work seems to have been done during the summer. Considerable open-cut work was in progress on Seattle Junior Creek.

RAMPART DISTRICT.

Placer mining in the Rampart district during 1912 was conducted on about the same scale as in 1911. No new discoveries were reported. Open-cut methods were used exclusively during the open season. The number of men engaged in mining varied from about 20 in winter to about 60 in summer.

On Quail Creek, in the Hess Creek basin, four outfits employing nine men in the winter and seventeen in the summer were busy. Several splash dams were successfully used to remove the overburden and concentrate the values sufficiently to allow them to be profitably recovered by shoveling into sluice boxes.

On Hunter Creek two hydraulic plants employing from four to six men each were in operation during the summer. Three or four men were also mining on one claim most of the winter. On Dawson Creek three or four men were mining a greater part of the winter.

Three outfits employing about fifteen men were working on Little Minook Creek during the summer and one outfit employing three men during the winter.

Slate Creek showed more than usual activity during the summer of 1912. At various points along the valley from Discovery to "No. 10 above" eight men were groundsluicing and shoveling into sluice boxes.

On Little Minook Junior Creek one party of four men was engaged in mining most of the summer and some work was in progress during the winter.

On Chapman Creek a party of four men worked throughout the year.

Along the bars of Minook some gold was recovered by means of rockers.

SALCHAKET AND TENDERFOOT DISTRICTS.

On Tenderfoot Creek two 40-horsepower hoisting plants, employing a total of about 30 men, were in operation during the summer of 1912. On Democrat Pup, which is a small fork of Banner Creek, one outfit employing eight men, with a 40-horsepower plant, was drifting most of the summer, and another employing four men was mining by open-cut methods. All four outfits were reported to have had a successful season.

No definite information is available concerning the amount of work done by the miners in the Salchaket basin, but it is believed that about the usual results were obtained.

WATER SUPPLY OF THE YUKON-TANANA REGION, 1912.

By C. E. Ellsworth and R. W. Davenport.

INTRODUCTION.

The present paper is the sixth annual report of water-supply investigations in the Yukon-Tanana region. Its purpose is to make available for immediate use the essential information that has resulted from the past season's work, in advance of the publication of the summary report that is now being prepared. The season of 1912 probably marks the close of water-supply studies in this region. The six years of records that are now available do not cover the area so well as might be desired and probably do not give the marginal limits of high and low stages that may occur on the streams investigated, but they do show that for a period of years the run-off has been uniformly low, and they should serve to guide development and should prevent unwise expenditures.

The writers received the hearty cooperation that has been so generally accorded to the work, and they regret that individual acknowledgment is not possible. Special thanks, however, are hereby extended to the following gage observers: Messrs. J. O. Anderson, C. N. Banks, John Barry, J. C. Brown, J. P. Carroll, Jack Clifford, Mrs. E. C. Curtis, Messrs. Earl Davis, Thomas Fitzgerald, Henry Friday, August Fritch, Arthur Froelich, H. M. Green, F. J. Herbster, Wm. Hugel, Alfred Johnson, J. A. Kemp, George Laughlin, John Lindguist, Jack McLin, E. D. Madison, Charles Martin, L. G. Michaels, Frank Miller, Frank Montgomery, James Murphy, John Olson, J. R. Parkin, John B. Powers, Charles Roan, John Roberts, Charles Rogers, Frank Rolf, Louis Schmidt, Henry Siemer, H. A. Stade, A. F. Stowe, F. C. Sutliff, W. P. Thrall, A. H. Turnbull, A. Van Curler, and E. D. Webster.

DATA AND METHODS.

DEFINITIONS OF TERMS.

The methods of carrying on the work and collecting the data were essentially the same as those used for similar work elsewhere in the United States, but were adapted to the special conditions found in Alaska.

In considering the water supply available for industrial or mining enterprises it is necessary to know the total amount of water flowing

into the streams, the daily distribution of the flow, and the conditions affecting the flow.

Several terms, such as second-foot, miner's inch, and gallons per minute, are used 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 unit for the rate of discharge of water flowing in a stream 1 foot wide and 1 foot deep at the rate of 1 foot per second. It expresses a rate of flow, and to obtain the actual quantity of water it is necessary to multiply the number of second-feet by the time in seconds.

"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 differ in different localities, 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.

"Sluice head," a term commonly used among placer miners in expressing a rate of flow, originated from the method of placer mining, in which water flowing through a series of sluice boxes is used for recovering the gold from the gravel. The rate of flow of water through the boxes is called a sluice head. This is not a definite term, because the rate of flow necessary for such mining methods varies with the size of the sluice boxes, the grade at which they are placed, and the character of the gravel. A sluice head under the varying conditions has been found to vary from 0.75 to 2.50 second-feet.

"Second-feet per square mile" is the average number of cubic feet of water flowing per second from each square mile of area drained, 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.

Gage heights and discharge measurements are the base data from which the daily discharge tables are computed.

Gage-height records show the fluctuations of the stream at a given point, and upon these depend the estimates of the discharge at the time the gage height was obtained.

DISCHARGE MEASUREMENTS.

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 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.

The engineers of the Survey are accustomed to use the current meter, though under exceptional conditions floats are sometimes used. 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.

If it is desired to estimate the discharge of a small creek or canal, a straight portion is selected in which the water runs smoothly and where the cross section of the stream is nearly uniform. This stretch is sometimes called the "run" and should be at least 50 feet in length if possible. Floats of any simple type may be used and the time of passage over this run is obtained. A number of determinations of the time of passage at different points across the stream are made and the average time in seconds required for one passage is computed. The length of the run, divided by this time in seconds and multiplied by 0.85, will give the approximate mean velocity in feet per second through the section. The average depth multiplied by the width of the stream gives the area of the cross section in square feet; this multiplied by the mean velocity gives the discharge in second-feet.

COMPARATIVE DISCHARGE FROM DIFFERENT AREAS.

The relation of discharge from different areas in the Yukon-Tanana region is shown graphically on Plate VII, on which are plotted curves of daily discharge per square mile of Fortymile River at Steel Creek, Birch Creek at Fourteenmile House, Crooked Creek at Central House, and Chatanika River below Faith Creek. The curves show clearly the high run-off during June at all the stations and the relatively high run-off from Chatanika River above Faith Creek during the entire season. The continued low run-off from Crooked Creek during July and the first week in August is of particular significance because of the extensive hydraulic mining that was attempted on the headwater tributaries of that creek. In this basin, where under present mining methods greater quantities of water are required than in any other section of the Yukon-Tanana region, the discharge per square mile during July, August, and September was the least of any basin at which records are available for 1912.

GAGING STATIONS.

In this paper the lists of gaging stations and measurement points are arranged in downstream order. The main stream of any river is determined by measuring or estimating the drainage area; that is, the headwater stream having the largest drainage area is considered the continuation of the main stream and local changes in name are disregarded. All stations from the source to the mouth of the main stream of the river are presented first, and the tributaries in regular order from source to mouth follow, the streams in each tributary basin being listed before those of the next basin below.

ACCURACY AND RELIABILITY OF DATA.

The accuracy of stream-flow data depends primarily on the natural conditions at the gaging station and on the methods and care with which the data are collected.

Errors due to natural conditions are those caused by lack of permanency in the channel and in the relation between discharge and stage. Frequent changes in channel are characteristic of most Alaskan streams, because of their steep grades, great fluctuation in stage, and easily eroded beds. Therefore in a season when freshets are of frequent occurrence the channels are subject to changes which often make the estimate of daily discharge only roughly approximate.

Errors due to the methods and care in the collection of data are caused, first, by errors in observation of stage; second, by errors in measurement of flow; and, third, by errors due to misinterpretation of stage and flow data. The more important of these are probably the errors of observation in stage. In the sudden and wide

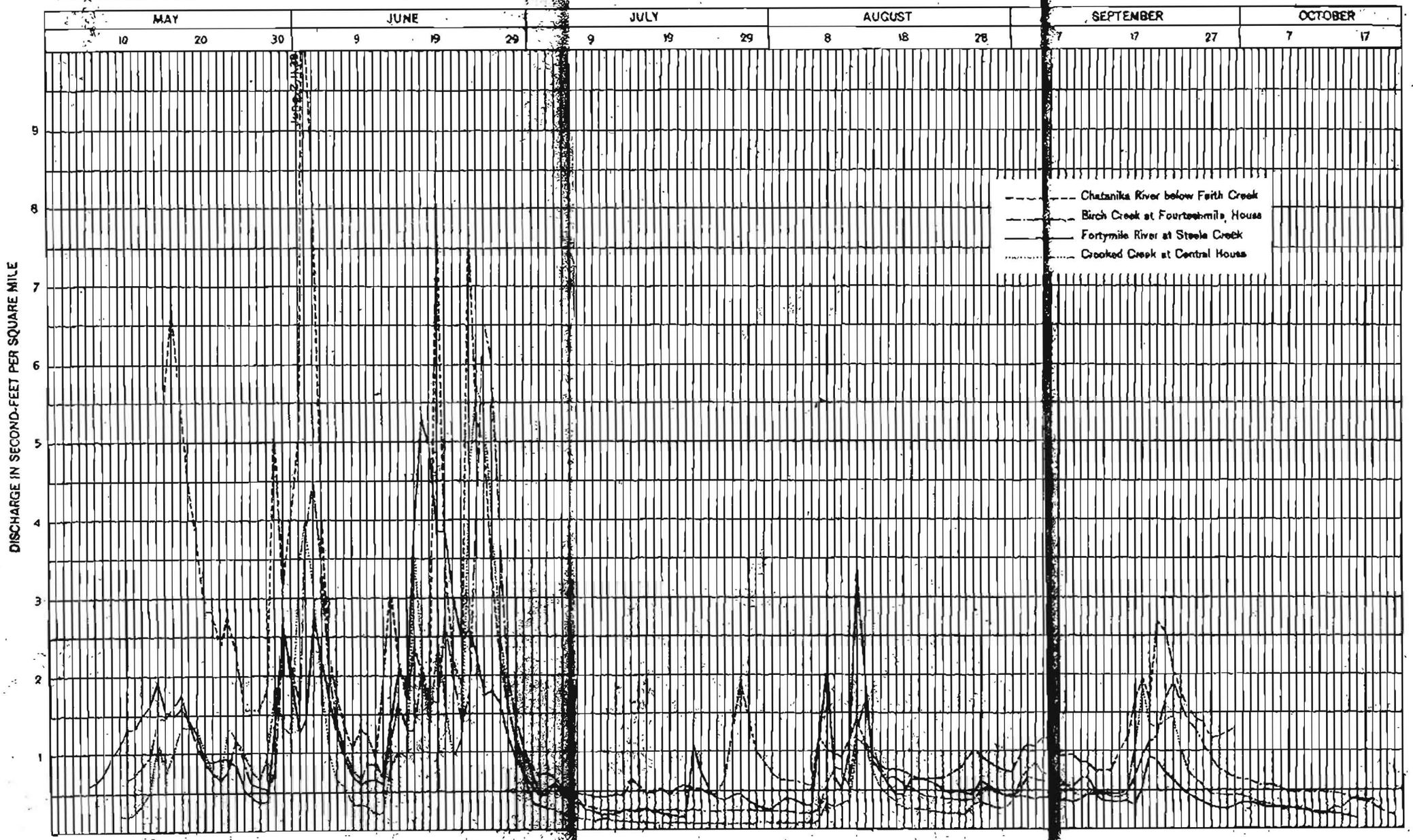


DIAGRAM SHOWING DISCHARGE, IN SECOND-FEET PER SQUARE MILE, OF STREAMS IN YUKON-TANANA REGION.

fluctuations peculiar to Alaskan streams, one or two observations of stage per day, which are all it is practicable to obtain at most of these stations, often do not give sufficient data for determining the mean stage for the day. In the mean discharge for the month, however, these errors are believed to be largely compensating.

The figure showing discharge per square mile and run-off in depth in inches may be subject to errors resulting from a drainage area which is not well defined by available maps and from the wide variation in contribution to run-off over the drainage area.

In the tables, "accuracy" shows the degree of reliability which, based on the above considerations, the record of the mean monthly flow is believed to possess. "A" indicates that the mean monthly flow is probably accurate within 5 per cent; "B," within 10 per cent; "C," within 15 per cent; "D," within 25 per cent. Special conditions are covered by footnotes.

CONVENIENT EQUIVALENTS.

1 second-foot equals 40 California miner's inches (law of March 23, 1901).
1 second-foot equals 38.4 Colorado miner's inches.
1 second-foot equals 40 Arizona miner's inches.
1 second-foot equals 7.48 United States gallons per second; equals 448.8 gallons per minute; equals 646,317 gallons for one day.
1 second-foot for one year covers 1 square mile 1.131 feet or 13.572 inches deep.
1 second-foot for one year equals 31,536,000 cubic feet.
1 second-foot for one day equals 86,400 cubic feet.
1,000,000 United States gallons per day equals 1.55 second-feet.
1 foot equals 0.3048 meter.
1 mile equals 1,60935 kilometers.
1 mile equals 5,280 feet.
1 acre equals 43,560 square feet.
1 cubic foot of water weighs 62.5 pounds.
1 horsepower equals 550 foot-pounds per second.
1 horsepower equals 76.0 kilogram-meters per second.
1 horsepower equals 746 watts.
1 horsepower equals 1 second-foot falling 8.80 feet.
1½ horsepower equals about 1 kilowatt.

To calculate water power quickly: $\frac{\text{Sec.-ft.} \times \text{fall in feet}}{11}$ = net horsepower on water wheel realizing 80 per cent of theoretical power.

PRECIPITATION.

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 these have been compiled by Abbe.[1]

[1] Abbe, Cleveland, jr., U. S. Geol. Survey Prof. Paper 45, pp. 189–200, 1906.

Monthly precipitation, in inches, at stations in Yukon-Tanana region, 1903–1912.

[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	.....	.....	.....
Chicken Creek	1911	.....	.....	.....	.....	.....	.45	1.08	.68	1.02	.50	.09	.09	.....
Do	1912	.18	.70	0	0	1.02	2.38	.68	2.51	[a]1.40	.....	.....	.....	.....
Cleary	1907	.....	.....	.....	.....	.....	.84	2.55	2.88	3.82	.....	.....	.....	.....
Crooked Creek	1911	.....	.....	.....	.....	.....	.....	2.52	2.18	1.30	.....	.....	.....	.....
Do	1912	.....	.....	.....	.....	.93	2.25	4.37	4.73	.61	.....	.....	.....	.....
Discovery Fork	1911	.....	.....	.....	.....	.....	1.24	2.36	2.33	1.15	.....	.....	.....	.....
Do	1912	.....	.....	.....	0	.53	1.81	2.32	2.47	.....	.....	.....	.....	.....
Eagle Creek	1908	.....	.....	.....	.....	.....	.....	.....	2.99	.....	.....	.....	.....	.....
Fairbanks	1904	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.10	2.00	.....
Do	1905	0.92	0.05	0.50	0.20	.....	.....	.....	2.63	.86	.....	1.20	.60	.....
		9.1	5.0	.5	2.0	.....	.....	.....	.....	.....	.....	12.0	5.1	.....
Do	1908	1.75	.37	.33	.10	0.36	1.05	2.82	1.50	.25	.30	.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
Do	1911	1.50	.80	.06	.....	.12	.....	2.16	2.30	1.60	.22	.29	1.23	.....
Do	1912	.10	.10	.95	0	1.22	3.15	.96	.82	1.16	.54	.24	.....	.....
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	.26	8.28
		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
Do	1911	.27	.24	.39	.97	2.87	1.26	2.36	2.65	1.21	.13	.29	.80	13.44
Do	1912	.....	.29	.11	Tr.	.43	2.09	2.52	2.48	.76	1.66	.....	.....	.....
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	.....	.....	.....	.....	[b]6.50	.99	.27	.....
		6.0	2.0	3.0	.....	.....	.....	.....	.....	.....	[b]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	.....
Do	1911	.94	1.63	.38	.77	1.53	.27	1.41	2.19	1.53	.44	.16	.....	.....
Do	1912	.08	.65	1.16	.02	1.18	2.06	1.59	3.24	1.15	.....	.....	.....	.....
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	[c]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	.29	.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	.....	.....	.....	.....	.....	.....	.....	.....

[a] Oct. 1–10. [b] Oct. 7–31. [c] July 16–31.

Monthly precipitation, in inches, at stations in Yukon-Tanana region, 1903–1912—Con.

Station.	Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Miller House..	1909	.....	.....	.....	.....	.....	.....	2.98	1.26	0.60	0.93	0.30	0.30	.....
		.....	.....	.....	.....	.....	.....	.....	.....	4.0	8.0	3.0	3.0	.....
Do.....	1910	.....	.....	.....	0.20	.....	1.94	2.37	.30	1.03	.....	.....	.....	.....
North Fork...	1905	.....	.....	.....	.....	.....	.....	.....	1.91	1.86	.....	.50	.20	.....
Do.....	1906	0.70	0.50	0.10	.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
Do.....	1911	1.05	2.20	.31	.75	.48	.34	.43	1.12	.79	.57	.21	.85	9.10
Do.....	1912	.13	.45	.81	.01	.86	3.03	.54	1.52	1.50	1.21	.....	.....	.....
Summit road house.....	1907	.....	.....	.....	.....	.....	.....	2.71	3.27	[a]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] September 1–22.

The records for 1912 indicate that the annual precipitation throughout the Yukon-Tanana region was very nearly normal. The winter precipitation, or snowfall, was somewhat below the average of the previous years of record, but the deficiency was offset by a summer precipitation generally above the normal. Although a summer precipitation greater than the normal is apparent both from the Weather Bureau records and from the records of stream flow its distribution during that period was very uneven. In some localities most of the rainfall was concentrated into a comparatively brief period, and water for mining was short during a large part of the summer. In other localities the even distribution of the rainfall throughout the summer and its adaptation to the needs of placer mining was marked.

With the accumulation of data on which conclusions may be based regarding precipitation in the Yukon-Tanana region certain deductions may be made. The mean yearly precipitation at each station in the Yukon-Tanana region is uniformly close to the average of the means of all the stations—that is, the records show no uniform difference in precipitation throughout the area. The precipitation at the different stations for a particular year may be influenced to some slight degree by certain phenomena which are general in their effect, and yet the precipitation for the year at different stations may vary

very widely. Precipitation is uniformly greater in the summer than in the remainder of the year. The conditions producing precipitation appear to be very local in character, the run-off of a given drainage area for a certain period perhaps differing widely from that of a near-by or adjoining area. The local nature of the showers, to which this is due, is noticeable to summer travelers in interior Alaska.

WATER POWER.

The records of stream flow gathered at points showing the greatest possibility for water-power development have been briefly summarized in the table below. In comparing the columns showing days of deficient discharge for several years on any stream, allowance should be made for difference in 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 years in which the records extend over shorter lengths 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 table gives the horsepower per foot of fall (80 per cent efficiency) that may be developed at different rates of discharge and shows the number of days on which the discharge and the corresponding horsepower were respectively less than the normal amounts, as given in the columns for "discharge" and "horsepower."

Estimated discharge and horsepower for Chatanika River and Birch Creek for 1907–1912.

Discharge in second-feet.	Horsepower per foot fall (80 per cent efficiency).	Days of deficient discharge.												
		Chatanika River below Faith Creek.					Chatanika River below Poker Creek.						Birch Creek above Sheep Creek.	
		June 21 to Sept. 30, 1907.	July 13 to Sept. 30, 19 .	May 25 to Sept. 25, 1910.	May 24 to Sept. 24, 1911.	May 15 to Sept. 30, 1912.	June 20 to Oct. 14, 1907.	May 16 to Oct. 21, 1908.	May 9 to Oct. 5, 1909.	May 17 to Oct. 28, 1910.	May 6 to Nov. 5, 1911.	June 13 to Oct. 26, 1912.	June 1 to Sept. 30, 1911.	May 8 to Sept. 22, 1912.
22	2	.....	.....	.....	0	.....	.....	.....	.....	.....	.....	.....	.....	.....
28	2.5	.....	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	.....	.....
33	3	0	.....	.....	14	.....	.....	.....	.....	.....	.....	.....	.....	.....
44	4	13	.....	0	22	.....	.....	.....	.....	.....	.....	.....	.....	.....
55	5	16	.....	14	25	0	.....	.....	.....	.....	.....	.....	.....	.....
66	6	29	.....	29	36	12	.....	.....	.....	.....	.....	.....	.....	.....
77	7	39	0	34	45	21	.....	.....	.....	.....	0	.....	0	.....
88	8	47	2	37	54	32	.....	.....	0	0	4	.....	3	.....
99	9	52	4	39	62	39	.....	.....	2	2	11	.....	7	.....
110	10	56	19	45	67	49	.....	.....	5	3	24	.....	13	.....
132	12	69	35	47	71	64	.....	.....	17	22	30	.....	20	.....
154	14	73	57	54	74	75	0	.....	26	40	41	0	23	.....
176	16	77	58	64	76	85	5	0	27	49	44	3	24	.....
198	18	78	65	69	77	90	17	5	39	55	59	16	29	0
220	20	82	66	79	79	98	27	27	46	60	66	31	32	8

Estimated discharge and horsepower for North Fork of Fortymile and Seventymile rivers for 1910–1912.

Discharge in second-feet.	Horsepower per foot fall (60 per cent efficiency).	Days of deficient discharge.					
		North Fork of Fortymile River at "Kink."			Seventymile River at the falls.		
		July 9 to Sept. 23, 1910.	May 19 to Sept. 20, 1911.	May 5 to Oct. 13, 1912.	June 16 to Sept. 30, 1910.	June 20 to Sept. 5, 1911.	May 3 to Oct. 18, 1912.
110	10	.....	.....	.....	.....	0	.....
132	12	.....	.....	.....	.....	5	0
154	14	.....	0	.....	.....	16	3
176	16	.....	1	.....	.....	30	6
198	18	.....	3	.....	0	42	8
220	20	0	5	.....	4	43	13
242	22	1	9	.....	10	47	19
264	24	4	10	.....	16	50	22
286	26	7	10	.....	22	57	26
308	28	11	17	.....	31	61	60
330	30	17	19	0	33	64	63
385	35	25	22	2	49	71	96
440	40	35	23	4	57	74	101

FORTYMILE DISTRICT.

GENERAL FEATURES.

In this paper the Fortymile district is considered as being the area drained by Fortymile River and its tributaries. This does not conform with the Fortymile precinct or recording district. The 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]

Fortymile River is tributary to Yukon River at longitude 140° 30′ west and latitude 64° 30′ north, about 50 miles below Dawson, Y. T., and about the same distance above Eagle, Alaska. Some of the river's southern tributaries rise in Canadian territory, and the main river enters Canadian territory about 23 miles above its mouth. Of its total drainage area of 6,350 square miles, about 4 per cent lies in Canadian territory. The area is roughly fan-shaped, its extreme radial dimension being approximately 100 miles. The stream flow is predominantly from west to east. About 40 miles in an air line from its mouth the river divides into two main forks, designated North and South, and these in turn subdivide somewhat symmetrically into other forks.

The tributaries interlock on the north with those of Mission Creek and Seventymile and Charley rivers in high rocky ridges, of which

[1] Map of Fortymile quadrangle (No. 640); can be obtained from the Director U. S. Geol. Survey, Washington, D. C., at 10 cents a copy. Map of Circle quadrangle; contained in U. S. Geol Survey Bull. 295, which can be consulted at public libraries; also in print as a separate publication, which can be obtained from the Director, U. S. Geol. Survey, price 50 cents. Map of 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: U. S. Geol. Survey Bull. 251, 1905.

Glacier Mountain is the most prominent, and on the west with Goodpaster, Volkmar, and Healy rivers, in mountains equally rugged. On the southeast the streams head in a country of relatively low relief, only a few miles from Tanana River. A moderately low dividing range, accentuated by several large dome-shaped mountains, separates them from the heads of Ladue Creek and Sixtymile River.

A prominent feature of the lower Fortymile Basin is the well-defined bench which marks the elevation of an earlier valley floor. In the vicinity of Steele Creek the bench is about 500 feet above the stream bed. The plane of the present valley floor and that of the older one coincide near the mouth of Kechumstuk Creek at an elevation of about 2,000 feet above sea level.

The following list gives the locations at which gaging stations were maintained or discharge measurements made in the Fortymile Basin during 1912. The relation of the various streams is shown by the indention.

Denison Fork at mouth.
South Fork of Fortymile River above Franklin Creek.
Fortymile River at Steele Creek.
- Deep Creek above ditch intake.
- Mosquito Fork below Kechumstuk Creek.
- Mosquito Fork above Chicken Creek.
  - Kechumstuk Creek at mouth.
  - Chicken Creek at mouth.
- Walker Fork above Poker Creek.
- Walker Fork above Cherry Creek.
- Walker Fork below Wade Creek.
  - Poker Creek at mouth.
  - Davis Creek one-half mile above mouth.
  - Wade Creek at claim "No. 10 above."
  - Wade Creek at mouth.
- Napoleon Creek at mouth.
- Buckskin Creek above Fortyfive Pup.
- Buckskin Creek at mouth.
  - Fortyfive Pup at claim No. 14.
- North Fork of Fortymile River at the "Kink."
  - Slate Creek at mouth.
  - North Fork of Fortymile River above Middle Fork.
    - North Fork of Fortymile River above Slate Creek.
    - Comet Creek at mouth.
    - Champion Creek at mouth.
  - Bullion Creek at mouth.
  - Hutchinson Creek below Confederate Creek.
  - Hutchinson Creek below Montana Creek.
  - Hutchinson Creek at mouth.
    - Confederate Creek at mouth.
    - Montana Creek at claim No. 7.
- King Solomon Creek at Liberty Cabin.
  - Liberty Fork at mouth.
  - Dome Creek at Auburn Mining Co. camp.
- Steele Creek at mouth.

Fortymile River—Continued.
Woods Creek above Camp Creek.
Canyon Creek below Squaw Gulch.
Canyon Creek at mouth.
Camp Creek at mouth.
Hall Creek at mouth.
Squaw Gulch at claim "No. 1 above."
Marion Creek at mouth.
Discovery Creek at mouth.
Smith Creek at mouth.
Moose Creek at mouth.
Moose Creek ditch 2 miles below intake.

SOUTH FORK OF FORTYMILE RIVER DRAINAGE BASIN.

The main stem of Fortymile River as determined by the area of drainage is, in downstream order, Denison Fork, South Fork, and Fortymile River, Denison Fork being joined by Mosquito Fork to form the South Fork.

Denison Fork has its source in a country characterized by wide swampy valleys which slope gently into fairly high mountains. The ridge separating its drainage from that of Tanana River parallels the Tanana at a distance of 4 to 10 miles. Its drainage area of 1,540 square miles is about equally divided between two forks, which unite to form the main stream about 12 miles above its mouth.

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. Its general direction of flow is northeast for about 75 miles, and its 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 Denison 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, the stream gradient abruptly decreases and the valley above this place is wide and 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 during wet seasons are said to be practically covered with water.

The principal tributaries to the South Fork below the junction of Denison and Mosquito forks are Atwater Creek, Walker Fork, Napoleon, Franklin, Buckskin, Uhler, and Butte creeks. The largest of these is Walker Fork, which is also the most important, because of the placer gold produced by its tributaries—Poker, Davis, Cherry, and Twelvemile creeks, Liberty Fork, and Wade Creek.

Monthly discharge of South Fork of Fortymile River at Franklin for 1910 to 1912.

[Drainage area, 3,180 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1910.					
July 9–31	912	237	502	0.158	0.13
August	5,120	134	911	.286	.33
September	631	420	487	.153	.17
The period, 84 days	5,120	134	647	.203	.63
1911.					
May 19–31	7,000	1,780	3,600	1.13	.55
June	3,240	340	970	.305	.34
July	4,140	340	932	.293	.34
August	495	200	326	.106	.12
September 1–20	495	200	299	.094	.07
The period, 125 days	7,000	200	970	.305	1.42
1912.					
May	5,540	735	2,280	0.717	0.83
June	12,600	1,790	5,340	1.68	1.87
July	1,930	230	635	.200	.23
August	6,100	440	1,380	.437	.50
September	2,350	710	1,140	.358	.40
October 1–13	820	370	532	.167	.08
The period, 166 days	12,600	230	2,020	.635	3.91

Daily discharge, in second-feet, of Denison Fork and South Fork for 1912.

Day.	Denison Fork at mouth.[a] [Drainage area, 1,540 square miles.]			South Fork of Fortymile River at Franklin.[b] [Drainage area, 3,180 square miles.]					
	June.	July.	Aug.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	970	.....	735	3,260	1,380	440	820	820
2	.....	650	135	930	4,170	1,260	520	820	820
3	.....	515	.....	1,060	7,600	1,190	660	820	660
4	.....	396	.....	1,320	7,180	865	710	820	610
5	.....	324	.....	1,320	5,960	550	710	710	610
6	2,360	260	.....	1,450	4,800	450	875	710	520
7	2,080	240	.....	1,580	3,680	450	1,150	710	480
8	1,840	220	.....	2,210	2,840	550	1,150	820	440
9	1,420	203	.....	3,540	2,350	500	1,150	930	440
10	1,240	190	.....	3,120	2,070	450	1,040	1,040	405
11	1,020	180	.....	3,610	1,790	405	2,350	1,100	370
12	1,420	170	.....	3,540	1,790	360	6,100	1,260	370
13	1,780	160	.....	3,540	2,770	360	4,310	1,200	370
14	1,720	148	.....	3,680	4,240	290	2,490	1,100	.....
15	1,840	.....	820	3,400	6,900	290	2,000	875	.....
16	4,960	.....	615	2,910	8,560	290	1,560	765	.....
17	6,500	.....	.....	2,700	12,600	290	1,260	765	.....
18	5,400	.....	.....	2,420	11,700	290	1,150	1,500	.....
19	4,280	.....	.....	1,930	9,040	230	1,260	1,930	.....
20	3,260	.....	.....	1,930	9,040	230	1,150	2,350	.....
21	2,940	.....	.....	1,930	7,180	230	1,150	2,000	.....
22	2,780	.....	.....	1,720	7,040	1,930	1,040	1,860	.....
23	2,780	.....	.....	1,450	6,900	1,100	930	1,500	.....
24	2,640	.....	.....	1,320	5,400	1,040	930	1,320	.....
25	2,080	.....	.....	1,190	4,310	930	930	1,100	.....
26	2,500	.....	.....	1,190	3,960	820	930	1,100	.....
27	2,360	.....	.....	1,060	3,680	710	1,040	1,100	.....
28	2,640	.....	.....	930	3,610	610	1,040	1,100	.....
29	1,600	.....	.....	3,750	3,330	520	1,040	1,100	.....
30	1,240	.....	.....	5,540	2,490	520	930	1,040	.....
31	.....	.....	.....	3,680	.....	610	930	.....	.....
Mean	2,590	330	.....	2,280	5,340	635	1,380	1,550	532
Mean, per square mile	1.68	.214	.....	.717	1.68	.200	.437	.487	.167
Run-off (depth in inches on drainage area)	1.56	.11	.....	.83	1.87	.23	.50	.54	.08
Accuracy	C.	A.	.....	B.	B.	A.	A.	A.	A.

[a] Daily discharges below 2,000 second-feet are believed to be accurate within 5 per cent.
[b] The rating curve is well defined for discharges below 10,000 second-feet.

Monthly discharge of Fortymile River at Steele Creek for 1910 to 1912.

[Drainage area, 5,890 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1910.					
June 28–30	13,900	11,500	12,900	2.19	0.24
July	8,480	570	1,830	.311	.36
August	7,740	470	1,750	.297	.34
September 1–23	3,240	860	1,520	.258	.22
The period, 88 days	13,900	470	2,100	.357	1.16
1911.					
May 16–31	33,400	5,840	12,900	2.19	1.30
June	17,100	1,360	5,680	.965	1.08
July	7,020	900	2,300	.390	.45
August	2,620	420	997	.169	.19
September 1–20	2,380	740	1,260	.214	.16
The period, 128 days	33,400	420	3,940	.669	3.18
1912.					
May 5–31	15,800	2,080	6,750	1.15	1.15
June	31,400	3,480	11,800	2.00	2.23
July	6,300	900	2,070	.351	.40
August	19,500	1,310	4,290	.728	.84
September	5,400	1,560	2,500	.424	.47
October 1–16	1,860	740	1,310	.222	.13
The period, 165 days	31,400	740	5,020	.852	5.22

Daily discharge, in second-feet, of Fortymile River at Steele Creek for 1912.[a]

[Drainage area, 5,890 square miles.]

Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	7,500	3,240	1,310	2,320	1,810
2	.....	8,220	2,620	1,960	2,380	1,860
3	.....	16,400	3,170	2,320	2,320	1,760
4	.....	12,700	3,400	2,200	2,200	1,610
5	3,400	9,840	2,680	1,860	2,260	1,510
6	3,720	7,260	2,200	1,710	2,260	1,460
7	4,310	5,400	1,710	7,020	2,200	1,460
8	5,620	4,040	1,410	12,100	2,140	1,360
9	6,540	3,480	1,260	3,880	1,960	1,260
10	7,740	3,720	1,140	2,960	2,020	1,180
11	7,740	3,880	1,100	5,840	2,500	1,140
12	8,740	3,480	1,140	19,500	2,440	1,100
13	9,280	8,220	1,310	11,200	2,080	1,020
14	11,200	12,100	1,310	5,080	1,960	860
15	9,000	11,000	1,360	4,310	1,910	860
16	8,740	22,000	1,410	3,400	1,960	740
17	9,280	31,400	1,220	2,680	1,760	.....
18	8,480	29,200	1,060	2,680	3,100	.....
19	7,260	22,600	940	3,720	5,400	.....
20	5,180	22,600	900	3,720	5,290	.....
21	5,180	18,000	940	3,720	4,400	.....
22	5,400	14,500	6,300	3,480	3,720	.....
23	5,400	15,100	4,220	2,960	3,100	.....
24	4,880	13,600	2,890	2,820	2,750	.....
25	3,030	10,100	2,380	2,960	2,320	.....
26	2,620	10,400	2,200	2,750	1,860	.....
27	2,080	9,560	2,500	2,680	1,710	.....
28	2,200	7,020	2,620	3,560	1,560	.....
29	8,220	5,180	2,140	3,170	1,560	.....
30	15,800	4,130	1,760	2,890	1,560	.....
31	11,200	.....	1,510	2,500	.....	.....
Mean	6,750	11,800	2,070	4,290	2,500	1,310
Mean per square mile	1.15	2.00	.351	.728	.424	.222
Run-off (depth in inches on drainage area)	1.15 A.	2.23 B.	.40 A.	.84 A.	.47 A.	.13 A.

[a] The rating curve is well defined below 20,000 second-feet.

Monthly discharge of Mosquito Fork below Kechumstuk Creek for 1910 to 1912.

[Drainage area, 824 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1910.					
July 7–31	325	57	149	0.181	0.17
August	234	40	92.2	.111	.13
September	80	37	57.4	.070	.08
October 1–3	49	37	42.3	.051	.006
The period, 89 days	325	37	94.8	.115	.386
1911.					
August 20–31	174	66	99.8	.121	.05
September	257	63	172	.209	.23
October 1–15	185	52	95.2	.116	.06
The period, 57 days	257	52	136	.165	.34
1912.					
June 9–30	4,030	322	1,900	2.31	1.89
July	660	77	210	.255	.29
August	1,000	84	292	.354	.41
September	780	296	459	.557	.62
The period, 114 days	4,030	77	613	.744	3.21

Daily discharge, in second-feet, of Mosquito Fork and Kechumstuk Creek for 1912.

Day.	Mosquito Fork below Kechumstuk Creek.[a] [Drainage area, 824 square miles.]				Kechumstuk Creek at mouth.[b] [Drainage area, 189 square miles.]			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1	.....	660	100	356	.....	84	27	102
2	.....	460	100	378	.....	72	27	102
3	.....	322	100	378	.....	80	27	102
4	.....	257	92	400	.....	72	27	102
5	.....	232	92	400	.....	77	27	102
6	.....	152	84	400	.....	61	27	102
7	.....	152	100	400	.....	44	40	102
8	.....	132	100	400	.....	24	40	102
9	400	132	100	460	91	16	40	80
10	356	116	400	460	93	16	240	130
11	322	132	1,000	400	84	27	600	102
12	540	132	620	460	284	24	420	80
13	1,020	132	540	460	492	24	335	80
14	1,610	174	460	460	778	21	236	80
15	1,180	185	378	460	492	16	205	80
16	4,030	152	296	460	2,230	16	116	80
17	3,790	132	198	460	1,450	16	102	80
18	3,020	198	244	460	694	8	205	80
19	3,120	220	244	400	946	8	196	102
20	2,720	270	270	356	568	8	175	130
21	2,720	270	296	296	420	8	145	130
22	2,420	270	296	780	420	12	116	252
23	2,520	270	322	700	736	16	160	74
24	2,420	296	339	660	420	24	175	84
25	2,330	244	322	540	335	27	130	67
26	2,420	244	296	540	284	29	160	64
27	1,700	163	296	460	278	29	130	64
28	1,340	132	322	460	214	26	102	63
29	1,020	100	339	460	145	23	102	61
30	820	77	339	460	116	20	102	60
31	.....	92	356	.....	.....	25	102	.....
Mean	1,900	210	292	459	525	307	146	94.6
Mean per square mile	2.31	.255	.354	.557	2.78	.162	.772	.500
Run-off (depth in inches on drainage area)	1.89	.29	.41	.62	2.27	.19	.89	.56
Accuracy	B.	A.	A.	A.	B.	A.	A.	A.

[a] The rating curve is well defined below 600 second-feet. Short periods in the first part of August are estimated.

[b] The rating curve is well defined for discharges below 500 second-feet.

Daily discharge, in second-feet, of Walker Fork and Wade Creek for 1912.

Day.	Walker Fork, above Poker Creek.[a] [Drainage area, 7.39 square miles.]			Wade Creek at claim No. 10, above.[b] [Drainage area, 23.1 square miles.]				
	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	Oct.
1	.....	.....	2.6	.....	1.0	15	10	25
2	.....	.....	2.6	.....	.8	38	9.3	25
3	.....	.....	3.4	.....	.8	9.3	9.3	21
4	.....	.....	2.6	.....	.8	9.3	9.3	21
5	.....	.....	4.2	.....	.8	6.9	9.3	18
6	4.8	.....	.....	10	1.0	21	9.3	18
7	.....	.....	.....	10	1.0	36	15	15
8	.....	10	.....	9.3	1.0	36	15	21
9	.....	10	.....	9.3	1.0	12	12	21
10	.....	10	.....	9.3	.4	15	15	20
11	.....	20	.....	4.2	1.0	68	12	20
12	.....	25	.....	2.3	1.0	96	12	.....
13	.....	15	.....	21	1.0	84	12	.....
14	.....	15	.....	18	2.3	84	12	.....
15	.....	10	.....	21	2.3	36	12	.....
16	.....	10	.....	47	4.2	21	9.3	.....
17	.....	7.0	.....	21	4.2	18	29	.....
18	.....	7.0	.....	18	4.2	15	96	.....
19	.....	7.0	.....	21	1.0	18	36	.....
20	.....	5.6	.....	21	1.0	15	48	.....
21	.....	7.0	.....	18	2.3	18	29	.....
22	.....	5.6	.....	15	36	12	29	.....
23	.....	5.6	.....	21	34	10	29	.....
24	.....	5.6	.....	25	21	10	25	.....
25	.....	4.2	.....	21	15	9.3	18	.....
26	.....	4.2	.....	18	9.3	10	18	.....
27	.....	4.2	.....	9.3	9.3	15	15	.....
28	.....	4.2	.....	9.3	6.9	16	15	.....
29	.....	4.2	.....	2.3	6.9	15	13	.....
30	.....	4.2	.....	2.3	4.2	15	29	.....
31	.....	3.4	.....	.....	4.2	15	.....	.....
Mean	.....	8.50	3.08	15.3	5.8	25.7	20.4	20.5
Mean per square mile	.....	1.15	.417	.662	.251	1.11	.883	.887
Run-off (depth in inches on drainage area)	.....	1.03	.08	.62	.29	1.28	.99	.36
Accuracy	.....	A.	A.	B.	B.	B.	B.	B.

[a] The rating curve is well defined for all stages occurring during the period of the record.
[b] The rating curve is well defined for discharges below 25 second-feet.

Daily discharge, in second-feet, of Buckskin Creek and Fortyfive Pup for 1912.

Day.	Buckskin Creek above Fortyfive Pup.[a] [Drainage area, 33 square miles.]				Fortyfive Pup at claim No. 14.[b] [Drainage area, 9.1 square miles.]				
	June.	July.	Aug.	Sept.	May.	June.	July.	Aug.	Sept.
1	.....	.....	.....	.....	.....	32	6	2.9	.....
2	.....	6.6	.....	.....	.....	49	6	18	.....
3	.....	.....	.....	.....	.....	23	4	24	.....
4	.....	5.2	17	.....	.....	20	4	21	.....
5	.....	3.8	13	.....	.....	20	4	30	.....
6	.....	.....	.....	.....	.....	18	4	43	.....
7	.....	.....	.....	.....	12	18	2	60	.....
8	.....	.....	.....	.....	12	16	2	27	.....
9	.....	.....	.....	.....	12	16	2	21	.....
10	.....	.....	.....	.....	12	14	2	18	.....

[a] The rating curve is well defined for all discharges reported.
[b] In June a shift occurred in the channel of this station, making prior records subject to considerable error. The rating curve for the remainder of the season is well defined below 20 second-feet. A considerable portion of the record for June and July is estimated.

Daily discharge, in second-feet, of Buckskin Creek and Fortyfive Pup for 1912—Continued.

Day.	Buckskin Creek above Fortyfive Pup. [Drainage area, 33 square miles.]				Fortyfive Pup at claim No. 14. [Drainage area, 9.1 square miles.]				
	June.	July.	Aug.	Sept.	May.	June.	July.	Aug.	Sept.
11					23	14	2	118	
12	19				32	14	1.8	50	
13				19	42	12	1.8	27	
14					49	35	1.8	24	
15		2.9			56	46	1.8	21	
16					42	77	1.8	15	
17			24		38	77	1.8	10	
18					32	77	1.8	10	18
19					32	70	1.8	8	
20			19		23	74	1.8	6	
21					29	40	24	6	
22					29	35	40	4	
23					23	30	24	4	
24					20	24	18	2.9	
25					17	60	12	2.9	
26					17	74	10	2.9	
27					12	40	8	4	
28					23	21	8	4	
29					46	14	6	4	
30					29	8	4	4	
31					17		4	4	
Mean					27.2	35.6	6.8	19.2	
Mean per square mile					2.99	3.91	.747	2.11	
Run-off (depth in inches on drainage area)					2.78	4.36	.86	2.43	
Accuracy					C.	C.	B.	B.	

Miscellaneous measurements in South Fork of Fortymile River drainage basin in 1912.

Date.	Stream and locality.	Discharge.	Drainage area.	Discharge per square mile.
		Sec.-ft.	*Sq. mi.*	*Sec.-ft.*
August 16	Deep Creek above ditch intake	0.24		
July 13	Mosquito Fork at Chicken, Alaska	169	1,120	0.151
July 15	Chicken Creek at mouth	.80	16.3	.049
June 5	Walker Fork, above Cherry Creek	25	15.8	1.58
June 10	....do	20	15.8	1.27
June 12	....do	16	15.8	1.01
July 6	....do	8	15.8	.506
August 8	....do	23	15.8	1.46
July 7	Walker Fork, below Wade Creek	41.9	406	.03
July 6	Poker Creek, at mouth	1.86	3.1	.600
Do	Davis Creek, ¼ mile above mouth	1.2	1.5	.800
July 7	Wade Creek, at mouth	1.81	50	.036
August 21	Buckskin Creek, at mouth	41.1	73.7	.558

NORTH FORK OF FORTYMILE RIVER DRAINAGE BASIN.

North Fork of Fortymile River drains an area of 2,120 square miles. The stream has its source in high, rugged mountains of elevations from 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 of lower Fortymile River.

The principal tributary and that representing the main stem of the stream is Middle Fork, locally known as Granite Fork. Its drainage

area is 1,110 square miles, which is 52 per cent of the total drainage of the North Fork. Its headwaters drain a country with wide flat valleys somewhat similar to those of Mosquito and Denison forks.

North Fork, above Middle Fork, locally known as Eureka Creek, has for its principal tributaries Slate, Comet, and Champion creeks. Below the junction of the two forks Bullion and Hutchinson creeks enter from the west.

Very few people live in the North Fork basin and only very meager stream-flow records are obtainable. Four stations were maintained on Hutchinson Creek, and miscellaneous measurements were made of some of the branches.

About 3 miles below the mouth of Hutchinson Creek the river originally followed a large meander known as the "Kink." Although the distance around was 2¾ miles, the two channels at the neck of the meander were separated by only a sharp rock ridge 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. 231.) Daily discharges at the "Kink" have been calculated from the records of Fortymile River at Steele Creek and of South Fork at Franklin. The drainage area of 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; and daily discharges were obtained by taking 74 per cent of the difference in discharge between the former and latter stations. The daily results are subject to considerable inaccuracy, but the larger errors involved should be compensated in the monthly means, which should have a probable error not greater than 15 per cent.

Daily discharge, in second-feet, of North Fork of Fortymile River at the "Kink" for 1912.

[Drainage area, 2,010 square miles.]

Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	3,140	1,380	644	1,110	733
2	.....	3,000	1,010	1,070	1,150	770
3	.....	6,510	1,470	1,230	1,110	814
4	.....	4,090	1,880	1,100	1,020	740
5	1,540	2,870	1,580	851	1,150	666
6	1,680	1,820	1,300	618	1,150	696
7	2,020	1,270	932	435	777	725
8	2,520	888	711	8,140	733	681
9	2,220	836	563	2,020	600	607
10	3,420	1,220	511	1,420	725	574
11	2,320	1,550	514	2,600	962	570
12	3,110	1,250	577	9,910	873	540
13	3,510	4,030	703	5,100	651	481
14	5,570	5,820	755	1,920	637	.....
15	4,140	3,040	792	1,710	766	.....

Daily discharge, in second-feet, of North Fork of Fortymile River at the "Kink" for 1912—Continued.

Day.	May.	June.	July.	Aug.	Sept.	Oct.
16	4,310	9,950	829	1,360	885	.....
17	4,180	13,900	688	1,050	736	.....
18	4,490	13,000	570	1,130	1,180	.....
19	3,940	10,100	525	1,820	2,570	.....
20	2,400	10,100	496	1,900	2,180	.....
21	2,400	8,000	525	1,900	1,780	.....
22	2,720	5,520	3,230	1,810	1,380	.....
23	2,920	6,070	2,310	1,500	1,180	.....
24	2,640	6,070	1,370	1,400	1,060	.....
25	1,360	4,280	1,070	1,500	903	.....
26	1,060	4,770	1,020	1,350	555	.....
27	755	3,610	1,320	1,210	452	.....
28	940	2,520	1,490	1,860	341	.....
29	3,310	1,370	1,200	1,580	341	.....
30	7,620	1,210	918	1,450	385	.....
31	5,570	.....	666	1,160	.....	.....
Mean	3,240	4,740	1,060	2,150	1,010	661
Mean per square mile	1.61	2.36	.527	1.07	.503	.329
Run-off (depth in inches on drainage area)	1.62	2.63	.61	1.23	.56	.16
Accuracy	C.	C.	C.	C.	C.	C.

Daily discharge, in second-feet, of Hutchinson Creek below Confederate and Montana creeks for 1912.

Day.	Hutchinson Creek below Confederate Creek.[a] (Drainage area, 16.6 square miles.)				Hutchinson Creek below Montana Creek.[b] (Drainage area, 29 square miles.)				
	May.	June.	July.	Aug.	May.	June.	July.	Aug.	Sept.
1	.....	37	4	42	.....	.....	.....	.....	14
2	.....	62	14	27	.....	.....	74	.....	.....
3	.....	37	14	18	.....	.....	.....	.....	.....
4	.....	32	8	18	.....	19	.....	.....	.....
5	.....	27	3	18	.....	.....	.....	15	11
6	.....	22	1.2	30	.....	.....	.....	.....	.....
7	.....	18	3	67	.....	.....	.....	104	.....
8	.....	22	4	52	.....	.....	.....	.....	.....
9	.....	18	4	42	.....	.....	.....	.....	.....
10	.....	14	4	37	.....	.....	.....	.....	.....
11	.....	6	6	126	.....	12	.....	170	.....
12	.....	57	4	52	.....	62	6.7	110	.....
13	.....	102	14	42	.....	.....	.....	.....	.....
14	.....	96	11	37	.....	170	.....	.....	.....
15	.....	151	11	27	.....	.....	.....	.....	.....
16	.....	62	6	27	74	110	7.6	.....	.....
17	.....	67	6	37	.....	224	.....	.....	.....
18	.....	22	4	27	94	.....	.....	34	.....
19	.....	22	3	27	.....	.....	.....	.....	.....
20	.....	27	4	27	104	.....	.....	.....	.....
21	.....	22	32	27	.....	.....	.....	.....	.....
22	.....	32	32	37	.....	.....	.....	.....	.....
23	42	47	27	37	84	.....	11	.....	.....
24	32	84	18	27	.....	.....	.....	.....	.....
25	47	84	14	27	.....	62	.....	31	.....
26	62	67	62	37	.....	.....	15	.....	.....
27	84	62	47	42	.....	.....	3	.....	.....
28	67	47	42	35	.....	.....	.....	.....	.....
29	67	18	37	35	.....	.....	.....	70	.....
30	47	4	27	35	.....	.....	3	.....	.....
31	37	.....	42	35	.....	.....	.....	.....	.....
Mean	53.9	45.6	16.4	37.2	.....	.....	.....	.....	.....
Mean per square mile	3.25	2.75	.988	2.24	.....	.....	.....	.....	.....
Run-off (depth in inches on drainage area)	1.09	3.07	1.14	2.58	.....	.....	.....	.....	.....
Accuracy	B.	B.	B.	B.	.....	.....	.....	.....	.....

[a] The curve is well defined for discharges below 40 second-feet.
[b] Discharges below 60 second-feet are probably accurate within 5 per cent.

Daily discharge, in second-feet, of Confederate and Montana creeks for 1912.

Day.	Confederate Creek at mouth.[a] [Drainage area 9 square miles.]			Montana Creek at claim "No. 7 above."[b] [Drainage area 5.9 square miles.]				
	June.	July.	Aug.	May.	June.	July.	Aug.	Sept.
1			11		14	4.0	3.8	3.8
2			6.4		25	24	3.8	3.8
3			5.1		15	16	3.8	3.8
4			5.1		14	8.0	3.8	3.8
5			5.1		11	3.8	3.8	3.8
6			15		9.0	3.0	20	
7			40		7.0	3.0	50	
8			24		9.0	3.0	22	
9			11		7.2	2.0	17	
10	4.9		7.9		5.6	2.0	17	
11			57		3.8	2.0	50	
12			50		27	2.0	22	
13			24		27	1.0	17	
14			18		50	1.0	14	
15			16	24	30	1.0	12	
16		2.8	16	27	22	1.0	10	
17		2.8	11	22	65	1.0	8.0	
18		2.8	16	20	35	1.0	5.9	
19		2.8	16	22	27	.9	5.9	
20		2.8		20	22	.8	5.9	
21		7.9		30	22	10	4.8	
22		9.4		27	24	8.0	4.8	
23		7.9		20	27	5.9	4.8	
24		6.4		15	24	5.9	3.8	
25		6.4		15	24	5.9	3.8	
26		13		12	18	5.9	3.8	
27		7.9		12	15	3.8	3.8	
28		7.9		27	10	3.8	3.8	
29		6.4		32	4.5	3.8	3.8	
30		11		18	4.5	3.8	3.8	
31		13		14		3.8	3.8	
Mean		6.95	18.7	21.0	20.0	11.0	4.55	3.8
Mean per square mile		.772	2.08	3.56	3.39	.771	1.86	.644
Run-off (depth in inches on drainage area)		.46	1.47	2.25	3.78	.89	2.14	.12
Accuracy		B.	B.	C.	C.	B.	B.	B.

[a] The rating table for this station is believed to be accurate within 5 per cent.
[b] The rating curve is fairly well defined below 20 second-feet. A considerable portion of this record is estimated, but the error involved is believed to be small.

Miscellaneous measurements in North Fork of Fortymile River drainage basin in 1912.

Date.	Stream and locality.	Discharge.	Drainage area.	Discharge per square mile.
		Sec.-ft.	*Sq. miles.*	*Sec.-ft.*
July 17	North Fork of Fortymile at "Kink"	541	2,010	0.269
July 19	Slate Creek at mouth	75.7	336	.225
July 18	North Fork of Fortymile above Middle Fork	250	724	.345
July 19	North Fork of Fortymile above Slate Creek	59.0	109	.541
Do	Comet Creek at mouth	36.4	60.5	.602
Do	Champion Creek at mouth	34.8	179	.194
July 18	Bullion Creek at mouth	5.54	34.3	.162
Do	Hutchinson Creek at mouth	11.2	71.3	.157

LOWER FORTYMILE RIVER BASIN.

Below the junction of North and South forks Fortymile River flows in a V-shaped valley about 500 feet below an old valley floor, where it is joined by O'Brien, Flat, Steele, Twin, Nugget, Canyon, Smith, Moose and Uncle Sam creeks. The largest of these is O'Brien Creek, which has for tributaries King Solomon Creek, Liberty Fork, Columbia, Alder, and Dome creeks. Moose Creek is almost entirely in Canadian territory. All these streams have heavy gradients and at their mouths have cut deeply into the high bench lands.

Daily discharge, in second-feet, of King Solomon Creek, Liberty Fork, and Dome Creek for 1912.

Day.	King Solomon Creek at Liberty Cabin.[a] [Drainage area, 54.2 square miles.]			Liberty Fork at mouth.[b] [Drainage area, 43.1 square miles.]			Dome Creek at Auburn Mining Co. camp.[c] [Drainage area, 24.9 square miles.]			
	June.	July.	Aug.	June.	July.	Aug.	June.	July.	Aug.	Sept.
1		10	64					2.2	9.0	11
2	98	10	64	36	11	390	47	2.2	8.4	8.4
3	153	15	33			30		2.2	8.4	8.4
4	30	10	30			30		2.2	7.2	11
5		10	26					1.1	7.2	11
6		9	30					1.1	7.2	8.4
7		9	396		11			1.1	35	14
8	64	9	171					1.1	30	11
9		7	98					1.1	25	14
10	30	5	80					1.1	20	17
11	26	9	112	8	11			1.1	47	14
12	22	9	230					1.1	41	17
13		8	136	14				2.2	35	11
14	30	8	86	14			6.0	2.2	31	11
15		8	74					2.2	27	11
16		7	69					2.2	24	11
17		7	56		24			2.2	22	20
18	30	7	45				6.0	2.2	20	31
19		10	42					2.2	18	23
20		15	36					2.2	16	27
21		56	32		200			27	17	20
22		52	30					24	16	15
23		48	28					21	12	10
24		44	26					18	10	10
25		38	24					15	10	10
26		34	22					12	10	10
27		30	38		96		8.4	11	8	10
28		30	32					10	8	10
29		28	26					10	8	8.4
30		26	20			21		10	7.2	8.4
31		24	22					9.0	11	
Mean	19.1	19.1	70.3				6.52	6.52	17.9	13.4
Mean per square mile		.352	1.30					.262	.719	.538
Run-off (depth in inches on drainage area)		.41	1.50					.30	.83	.60
Accuracy		B.	B.					C.	B.	B.

[a] The rating is well defined below 140 second-feet. A number of periods in the July record are estimated.
[b] The rating curve is well defined below 50 second-feet.
[c] The rating curve is well defined for discharges below 30 second-feet. A considerable portion of the record for July and August is estimated.

Daily discharge, in second-feet, of Steele, Canyon, and Squaw creeks for 1912.

Days.	Steele Creek at mouth.[a] [Drainage area 12.5 square miles.]				Canyon Creek below Squaw Creek.[b] [Drainage area 56.5 square miles.]				Squaw Creek at claim No. 1 above.[c] [Drainage area 24.4 square miles.]			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1	.....	1.3	1.8	3.7	.....	.....	.....	27	.....	14	79	14
2	.....	1.0	4.6	3.7	.....	.....	.....	27	.....	14	67	10.5
3	38	1.3	2.3	4.6	.....	.....	.....	23	.....	10.5	47	14
4	6.6	1.3	2.3	3.7	.....	.....	.....	31	24	5.5	39	14
5	9.6	.8	2.3	3.7	46	7.8	.....	27	24	2.2	57	18
6	5.5	.8	3.7	3.7	.....	.....	195	36	18	2.2	79	18
7	3.7	.8	26	3.7	.....	.....	155	67	18	2.2	57	24
8	3.7	.6	11	3.7	.....	.....	99	67	18	2.2	24	24
9	4.6	.4	7.8	3.7	.....	.....	67	99	18	2.2	24	24
10	2.3	.4	7.8	5.5	.....	.....	67	113	14	2.2	24	18
11	2.3	.2	87	5.5	.....	.....	300	106	14	3.0	120	18
12	1.8	.2	46	4.6	.....	.....	171	67	18	3.7	108	14
13	2.3	.3	9.6	5.5	.....	.....	148	36	24	5.5	79	14
14	14	.4	6.6	6.6	.....	.....	106	51	24	5.5	62	10.5
15	11	.4	7.8	5.5	.....	.....	73	36	31	7.7	47	10.5
16	30	.3	6.6	6.6	.....	.....	67	27	39	7.7	39	10.5
17	18	4	5.5	7.8	.....	.....	51	41	31	10.5	31	18
18	14	.4	7.8	97	.....	.....	51	235	24	10.5	35	175
19	14	.4	7.8	92	.....	.....	67	106	24	10.5	39	100
20	14	.4	6.6	38	.....	.....	51	141	31	10.5	31	100
21	14	1.0	3.7	26	.....	.....	41	106	52	24	14	80
22	14	20	5.5	20	.....	.....	41	61	62	57	14	79
23	11	5.5	5.5	11	.....	.....	41	41	47	67	10.5	47
24	5.5	5.5	4.6	7.8	.....	.....	31	51	35	57	10.5	39
25	3.7	3.7	4.6	5.5	.....	.....	27	36	24	57	10.5	31
26	4.6	2.3	3.7	5.5	.....	.....	23	67	24	47	16	24
27	3.7	23	3.7	5.5	.....	.....	41	61	18	47	24	18
28	2.3	5.5	4.6	5.5	.....	.....	41	.....	14	39	24	14
29	1.3	3.7	3.7	4.6	.....	.....	36	.....	14	39	24	10.5
30	.8	2.3	4.6	3.7	.....	.....	27	.....	14	47	18	10.5
31	.....	1.3	3.7	.....	.....	.....	36	.....	.....	57	14	.....
Mean	9.2	2.8	7.4	13.3	.....	.....	79.0	66.1	25.9	21.6	40.9	33.4
Mean per square mile	.736	.222	.592	1.06	.....	.....	1.40	1.17	1.06	.885	1.68	1.37
Run-off (depth in inches on drainage area)	.77	.26	.68	1.18	.....	.....	1.35	1.17	1.06	1.02	1.94	1.53
Accuracy	A.	A.	A.	A.	.....	.....	C.	C.	B.	B.	C.	C.

[a] Discharges below 50 second-feet are believed to be accurate within 5 per cent.

[b] The daily discharges at this station were determined by a gage height record taken at the mouth of Canyon Creek and by discharge measurements made at the point for which the record is given. The relation between the gages at the two points was obtained. The results are probably accurate within 15 per cent.

[c] The rating curve was well defined for the first half of the summer. Changes in the channel the latter part of the season affected the rating, but results are probably accurate within 15 per cent.

Miscellaneous measurements in Lower Fortymile River drainage basin in 1912.

Date.	Stream and locality.	Discharge.	Drainage area.	Discharge per square mile.
		Sec.-ft.	*Sq. mi.*	*Sec.-ft.*
August 26	Canyon Creek at mouth	49.2	86.5	0.569
August 27	....do	59.0	86.5	.683
July 5	Woods Creek above Camp Creek	1.01	6.1	.166
Do	Camp Creek at mouth	2.00	5.4	.370
Do	Hall Creek at mouth	3.90	12.0	.325
August 26	Marion Creek at mouth	2.5	11.0	.227
August 29	Discovery Creek at mouth	1.1	3.4	.324
August 28	Smith Creek at mouth	7.5	28.4	.264
Do	Moose Creek at mouth	18.0	.....	.....
Do	Moose Creek ditch 2 miles below intake	.70	.....	.....

HYDROGRAPHS OF STREAMS IN THE FORTYMILE DISTRICT.

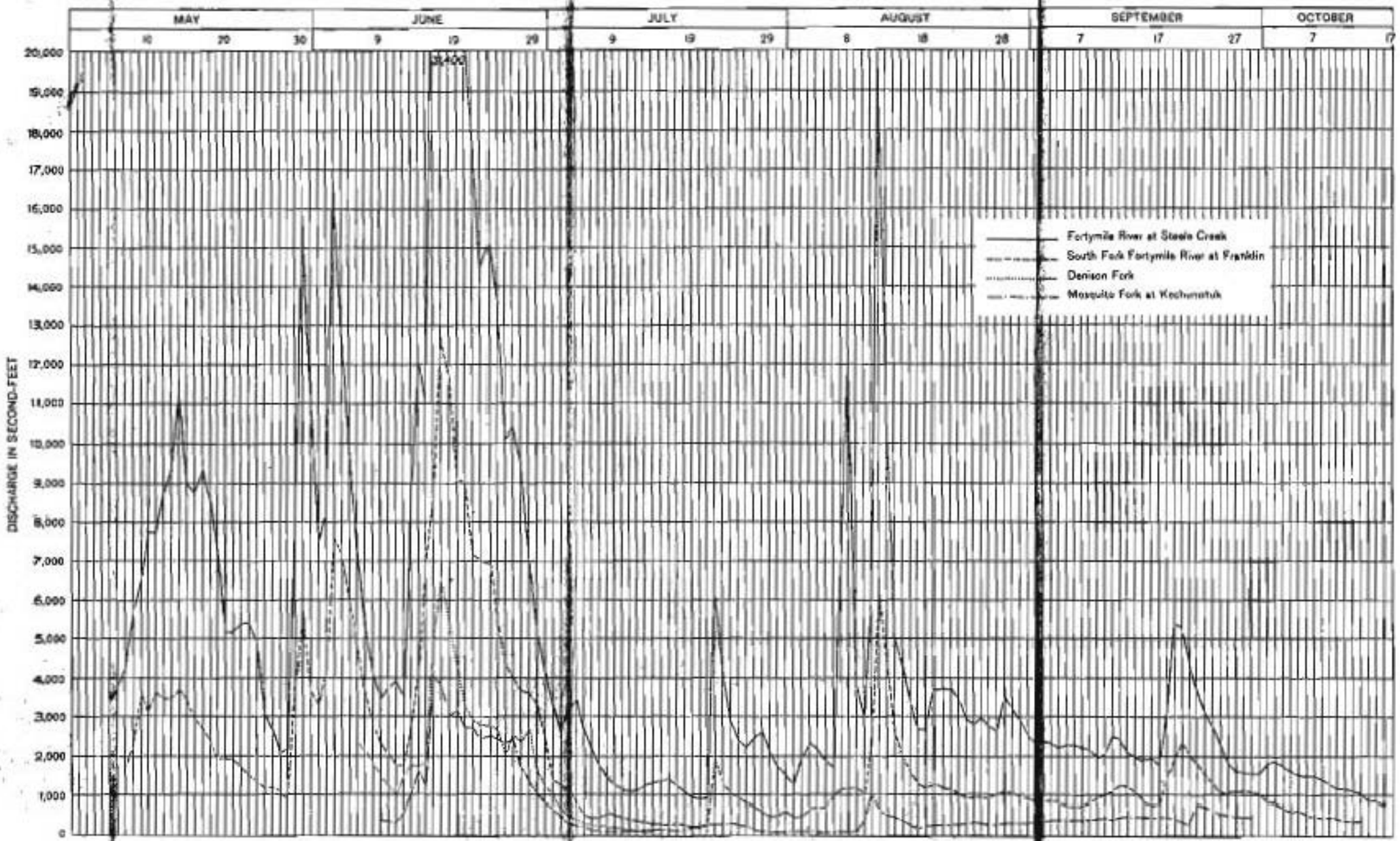
Hydrographs showing the daily discharge of Fortymile River at Steele Creek, South Fork of Fortymile River at Franklin, Denison Fork at mouth, and Mosquito Fork at Kechumstuk for 1912 are given on Plate VIII. These hydrographs show clearly the sudden and wide fluctuations peculiar to these northern streams. They show also that most storm waves extend over the entire Fortymile basin, though their intensity of precipitation may vary considerably with locality. It is interesting to note that although the drainage area of South Fork at Franklin forms more than half of that of Fortymile River at Steele Creek, the discharge from it is much less than half the discharge of Fortymile. This fact, which is also evident in the records for 1910 and 1911, is believed to be attributable to two causes: (1) South Fork basin contains an extensive flat swampy area, which affords much storage and a consequent large evaporation loss, whereas North Fork basin is more precipitous and drains more quickly, allowing less opportunity for evaporation; (2) the general elevation of the South Fork basin is less than that of the North Fork and therefore the precipitation is probably less. It is believed that these observations are verified by a study of the hydrographs.

SEVENTYMILE DISTRICT.

The Seventymile district comprises the area drained by Seventymile River and its tributaries. It adjoins the Eagle district on the north and borders the lands drained by tributaries of North Fork of Fortymile River. It lies within the Eagle precinct, and Eagle is the supply point for all the mines. The area has been topographically surveyed and is shown on the Geological Survey maps of the Fortymile and Circle quadrangles.

Seventymile River drains an area of about 700 square miles, practically three-fourths of which lies south of the river. The headwaters of the main river lie in the high rugged divide separating the basins of Seventymile and Charley rivers. Seventymile River drains the eastern slope of this divide and flows eastward for about 60 miles to a point 4 miles from its mouth, where it makes a right-angle turn and flows northward, joining the Yukon about 20 miles below Eagle.

The principal southern tributaries of Seventymile River, beginning at its headwaters, are Diamond Fork, Flume, Alder, Deep, Nugget, Granite, Green, Sonickson, Mogul, and Bryant creeks. Of these streams, Granite and Mogul creeks furnish a steady supply of water to the main river. Both creeks have a heavy fall, but no workable placers have yet been found on them. The heavy timber on Mogul Creek now supplies some large saw logs to the district. The tributaries of the Seventymile from the north are small, short streams,



HYDROGRAPH SHOWING DAILY DISCHARGE OF FORTYMILE RIVER, SOUTH FORK OF FORTYMILE RIVER, DENISON FORK, AND MOSQUITO FORK 1912.

usually falling to a minimum as soon as the snow leaves the ridges. They are Barney, Washington, Broken Neck, Crooked, and Fox creeks—all containing workable placers.

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 it drops 600 feet in 15 miles.

The following list gives the locations at which gaging stations were maintained or discharge measurements were made in 1912 in the Seventymile district. The relation of the tributaries is shown by the indention.

Seventymile River above Flume Creek.
Seventymile at the falls.
- Flume Creek one-fourth mile above mouth.
- Alder Creek at claim "No. 7 above."
- Deep Creek one-half mile above mouth.
- Nugget Creek at mouth.
- West Fork of Granite Creek 1½ miles above forks.
- Granite Creek at mouth.
  - East Fork at Granite Creek 1 mile above forks.
- Barney Creek at mouth.
  - Barney Creek ditch.
- Sonickson Creek above ditch intake.
- Washington Creek at mouth.
  - Washington Creek ditch at intake.
- Broken Neck Creek at mouth.
- Mogul Creek at mouth.
- Crooked Creek below Eldorado Creek.
- Fox Creek at Rolf's claim.
- Bryant Creek 2 miles above mouth.
- Rock Creek at bridge.

Monthly discharge of Seventymile River at the falls for 1910 to 1912.

[Drainage area, 465 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1910.					
June 16–30	2,250	340	851	1.83	1.02
July	1,350	208	402	.865	1.00
August	4,430	208	719	1.55	1.79
September	1,600	225	626	1.35	1.51
The period, 107 days	4,430	208	619	1.33	5.32
1911.					
June 20–30	1,050	410	737	1.58	.64
July	1,550	130	344	.739	.85
August	1,130	110	306	.659	.76
September 1–25	442	130	219	.471	.43
The period, 98 days	1,550	110	344	.740	2.68
1912.					
May 3–31	1,560	254	435	.935	1.01
June	1,670	148	603	1.30	1.45
July	3,400	148	573	1.23	1.42
August	8,150	376	1,180	2.54	2.93
September	376	300	329	.708	.79
October 1–18	336	300	302	.650	.44
The period, 169 days	8,150	148	593	1.28	8.04

Daily discharge, in second-feet, of Seventymile River at the falls for 1912.[a]

[Drainage area, 465 square miles.]

Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	528	214	642	376	300
2	.....	584	227	737	376	300
3	336	584	584	622	376	336
4	336	318	399	473	376	300
5	300	214	268	392	376	300
6	268	168	202	486	376	300
7	254	148	168	8,150	376	300
8	254	190	168	2,980	376	300
9	336	399	148	1,930	336	300
10	318	612	148	1,440	336	300
11	284	528	214	4,170	336	300
12	300	1,670	376	2,780	336	300
13	356	1,300	300	1,450	336	300
14	474	1,560	254	912	300	300
15	336	1,170	336	635	300	300
16	336	1,170	227	629	300	300
17	399	727	190	541	300	300
18	356	584	227	527	336	300
19	318	528	240	777	336	.....
20	300	474	214	640	300	.....
21	336	448	3,400	528	300	.....
22	422	698	2,100	474	300	.....
23	474	474	1,250	474	300	.....
24	556	448	1,300	698	300	.....
25	268	474	1,020	698	300	.....
26	300	640	786	528	300	.....
27	336	640	816	474	300	.....
28	422	356	612	474	300	.....
29	1,560	240	474	422	300	.....
30	1,250	214	422	376	300	.....
31	816	.....	474	376	.....	.....
Mean	435	603	573	1,180	329	302
Mean per square mile	.935	1.30	1.23	2.54	.708	.650
Run-off (depth in inches on drainage area)	1.01	1.45	1.42	2.93	.79	.44
Accuracy	A.	A.	B.	B.	A.	A.

[a] The rating curve is well defined below 1,500 second-feet. The record for Aug. 1–19 is estimated by comparison with the hydrographs of Flume, Adler, Washington, and Crooked creeks.

Daily discharge, in second-feet, of Flume and Alder creeks for 1912.

Day.	Flume Creek one-fourth mile above mouth.[a] [Drainage area, 36.7 square miles.]					Alder Creek at claim "No. 7 above."[b] [Drainage area, 11.8 square miles.]					
	May.	June.	July.	Aug.	Sept.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	.....	.....	48	30	.....	12	5.5	26	9.3	7.3
2	.....	.....	.....	53	30	.....	17	7.1	26	11	8.6
3	.....	.....	.....	40	30	.....	13	9.5	16	12	9.8
4	.....	.....	.....	33	33	.....	7.9	8.5	12	12	7.3
5	.....	.....	.....	27	33	.....	5.9	7.1	9.5	12	8.6
6	.....	.....	.....	33	33	.....	5.2	5.5	12	11	7.3
7	.....	.....	.....	735	33	.....	4.1	4.1	162	9.8	7.3
8	.....	.....	.....	280	33	.....	9.5	3.8	76	10	7.3
9	.....	.....	.....	190	.....	12	16	3.8	42	10	6.9
10	.....	.....	.....	98	.....	2.5	16	12	28	11	6.3
11	.....	.....	.....	379	.....	3.2	22	12	88	9.8	5.3
12	.....	.....	.....	264	.....	3.8	82	9.5	66	12	6.3
13	.....	.....	.....	120	.....	5.2	42	7.5	40	12	6.3
14	.....	.....	.....	68	.....	6.5	32	7.1	28	9.8	5.7
15	.....	.....	.....	40	.....	5.2	30	5.5	22	9.8	.....
16	.....	.....	.....	44	.....	7.5	21	5.2	21	9.8	.....
17	.....	.....	.....	40	.....	6.5	13	5.2	17	9.8	.....
18	.....	.....	.....	36	.....	7.9	10	4.6	16	9.8	.....
19	.....	.....	.....	48	.....	5.2	9.1	3.8	15	9.8	.....
20	.....	.....	.....	40	.....	5.5	7.9	4.6	13	8.6	.....
21	.....	.....	396	33	.....	6.5	7.1	130	12	9.3	.....
22	.....	.....	174	33	.....	7.5	7.9	76	11	9.8	.....
23	.....	.....	146	30	.....	9.1	11	38	11	9.8	.....
24	.....	.....	133	40	.....	5.9	13	42	17	7.3	.....
25	.....	30	68	40	.....	5.9	13	24	16	6.3	.....
26	19	.....	48	40	.....	5.5	15	16	14	7.3	.....
27	.....	.....	36	33	.....	7.1	14	12	12	8.6	.....
28	.....	.....	30	33	.....	9.5	9.5	9.5	12	7.3	.....
29	.....	.....	30	30	.....	47	7.1	9.1	10	6.9	.....
30	.....	.....	33	30	.....	32	5.9	8.5	10	7.3	.....
31	.....	.....	40	30	.....	14	16	16	10	.....	.....
Mean	.....	.....	103	96.4	31.9	9.6	16.0	16.5	24.9	9.6	7.2
Mean per square mile	.....	.....	2.80	2.63	.869	.813	1.36	1.40	2.11	.814	.610
Run-off (depth in inches on drainage area)	.....	.....	1.14	3.03	.26	.70	1.52	1.61	2.43	.91	.32
Accuracy	.....	.....	B.	B.	B.	B.	B.	B.	B.	B.	B.

[a] The rating curve is fairly well defined for discharges below 400 second-feet.
[b] The discharges for this station are probably accurate within 5 per cent.

Daily discharge, in second-feet, of Barney Creek ditch, Sonickson and Washington creeks, for 1912.

Day.	Barney Creek ditch.					Sonickson Creek above ditch intake. [Drainage area 12.6 square miles.]			Washington Creek at mouth.[a] [Drainage area 15.6 square miles.]				
	May.	June.	July.	Aug.	Sept.	May.	June.	July.	May.	June.	July.	Aug.	Sept.
1	.....	5.1	0.3	0.7	1.4	.....	.....	3.7	.....	5	0.8	5.2	6.5
2	.....	5.1	.3	.7	1.4	.....	.....	.....	.....	34	51	11	8.8
3	.....	4.7	.3	.6	1.4	.....	14	.....	.....	10	21	11	11
4	.....	3.1	.3	.5	1.4	.....	.....	.....	.....	13	10	8.8	6.5
5	.....	3.1	.4	.3	1.4	.....	.....	7.7	.....	5	8.2	6.5	6.5
6	.....	4.1	.3	3.1	1.4	.....	4.8	.....	.....	5	3.3	11	4.5
7	.....	4.1	.2	7.9	.....	.....	.....	4.2	.....	5	1.3	99	2.5
8	.....	3.1	.3	6.2	.....	.....	8.6	.....	.....	16	1.3	46	2.5
9	.....	3.1	.5	6.1	.....	.....	.....	.....	.....	34	.8	28	2.5
10	.....	2.2	.7	5.1	.....	.....	.....	.....	.....	15	1.3	19	2.5
11	.....	2.2	1.4	4.1	.....	.....	.....	.....	.....	10	6.3	64	2.5
12	.....	1.4	2.2	3.2	.....	.....	36	8.6	.....	18	6.3	34	2.0
13	.....	1.4	2.2	3.1	.....	.....	.....	.....	.....	10	4.8	25	2.0
14	.....	1.4	2.0	3.1	.....	.....	.....	.....	.....	8.2	8.2	16	2.0
15	.....	.7	1.5	2.9	.....	.....	.....	.....	.....	6.3	6.3	11	2.0
16	.....	.4	1.4	2.2	.....	.....	.....	.....	.....	3.3	4.8	8.8	2.0
17	.....	.3	1.0	2.2	.....	.....	.....	.....	.....	2.3	10	6.5	2.0
18	.....	.5	.8	2.6	.....	.....	.....	11	.....	1.3	10	11	2.0
19	.....	3.1	.6	3.1	.....	.....	.....	.....	.....	1.3	12	19	2.0
20	.....	3.1	.7	4.1	.....	.....	.....	.....	.....	.8	10	16	2.0
21	.....	4.1	6.7	3.1	.....	.....	.....	135	.....	1.3	100	14	2.0
22	.....	4.3	6.1	3.1	.....	.....	9.8	.....	.....	3.3	28	16	2.0
23	.....	.3	5.6	3.1	.....	.....	7.7	.....	.....	6.3	22	11	2.0
24	.....	.3	5.1	2.6	.....	4.8	.....	.....	.....	8.0	16	8.8	2.0
25	0.3	.4	3.2	2.5	.....	4.2	.....	.....	.....	10	11	6.5	2.0
26	.3	1.4	3.1	2.4	.....	.....	.....	.....	.....	10	11	11	1.5
27	.3	5.1	3.1	2.2	.....	4.2	.....	.....	.....	12	8.8	8.8	1.5
28	.3	4.1	2.2	1.8	.....	.....	.....	.....	.....	8.0	6.5	6.5	1.5
29	1.4	2.2	1.8	1.6	.....	55	6.8	.....	.....	6.0	5.2	8.8	1.5
30	5.1	.3	1.4	1.6	.....	27	.....	.....	25	3.0	4.0	8.8	1.5
31	4.6	.....	.8	1.4	.....	.....	.....	.....	10	.....	4.0	6.5	.....
Mean	1.76	2.49	1.82	2.81	1.40	.....	.....	.....	.....	9.0	12.7	17.7	3.1
Mean per square mile	.....	.....	.....	.....	.....	.....	.....	.....	.....	.577	.814	1.13	.199
Run-off (depth in inches on drainage area)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.64	.94	1.30	.22
Accuracy	B.	B.	B.	B.	B.	.....	.....	.....	.....	C.	C.	C.	C.

[a] The channel at this station shifted considerably throughout the summer. The rating curve is believed to be fairly well defined below 25 second-feet. Beginning September 2, about 3 second-feet were diverted from the creek about one-half mile above the gage.

Discharge, in second-feet, of Crooked and Fox creeks for 1912.

Day.	Crooked Creek below Eldorado Creek.[a] [Drainage area 17.2 square miles.]					Fox Creek at Rolf's claim.[a] [Drainage area 8.3 square miles.]				
	May.	June.	July.	Aug.	Sept.	May.	June.	July.	Aug.	Sept.
1	.....	5.0	3.0	16	10	.....	2.4	1.0	7.0	5.3
2	.....	24	5.0	19	10	.....	11.5	2.9	6.0	5.3
3	.....	24	10.8	17	9	.....	5.4	5.4	6.0	5.3
4	.....	9.5	6.0	16	10	.....	2.9	2.9	6.0	5.3
5	.....	7.0	4.0	14	10	.....	1.6	1.6	6.0	5.3
6	.....	5.0	3.0	16	9	.....	1.0	1.0	6.0	.....
7	.....	3.0	2.0	208	9	.....	1.0	1.0	21	.....
8	.....	22	1.0	38	9	.....	5.4	.8	15	.....
9	.....	41	1.0	26	10	.....	10.2	.8	10	.....
10	.....	26	2.0	23	9	.....	6.2	1.6	10	.....
11	.....	14	4.0	86	9	.....	3.4	4.7	18	.....
12	.....	16	9.5	47	9	.....	2.9	4.7	18	.....
13	.....	14	5.0	30	8	.....	2.9	2.9	14	.....
14	.....	9.5	8.2	23	8	.....	2.4	6.2	11	.....
15	7.0	9.5	8.2	21	8	.....	2.9	4.7	10	.....
16	6.0	14	6.0	19	9	.....	4.7	2.9	10	.....
17	5.0	9.5	8.2	17	10	.....	2.4	2.9	10	.....
18	4.0	7.0	7.0	15	12	.....	1.6	3.4	10	.....
19	4.0	6.0	6.0	33	12	.....	2.9	2.9	11	.....
20	4.0	6.0	8.2	23	10	.....	2.0	4.0	9.0	.....
21	3.0	6.0	173	23	10	.....	1.6	23	10	.....
22	3.0	9.5	45	21	10	1.6	2.4	16	9.0	.....
23	3.0	8.2	27	17	9	1.3	2.4	11	8.0	.....
24	3.0	7.0	23	17	.....	1.0	3.4	12	8.0	.....
25	2.0	10.8	17	15	.....	1.0	4.7	9.0	7.0	.....
26	2.0	22	21	15	.....	1.0	5.4	12	6.0	.....
27	2.0	12	17	14	.....	1.0	3.4	10	6.0	.....
28	2.0	7.0	16	14	.....	1.3	2.0	8.0	6.0	.....
29	22	5.0	17	12	.....	11.5	1.6	8.0	6.0	.....
30	14	4.0	16	12	.....	5.4	1.0	8.0	5.3	.....
31	7.0	.....	14	10	.....	2.9	.....	6.0	5.3	.....
Mean	5.47	12.1	15.9	28.3	9.52	2.80	3.45	5.85	9.37	5.30
Mean per square mile	.318	.704	.924	1.65	.553	.337	.416	.705	1.13	.639
Run-off (depth in inches on drainage area)	.20	.79	1.07	1.90	.47	.13	.46	.81	1.20	.12
Accuracy	B.	B.	C.	C.	B.	C.	C.	C.	C.	C.

[a] The channel was subject to shifts during the latter half of the season. The results are believed to be accurate within 15 per cent.

Miscellaneous measurements in Seventymile River drainage basin in 1912.

Date.	Stream and locality.	Discharge.	Drainage area.	Discharge per square mile.
		Sec.-ft.	*Sq. mi.*	*Sec.-ft.*
June 25	Seventymile River above Flume Creek	156	129	1.21
July 28	....do	201	129	1.56
August 18	....do	188	129	1.46
August 30	....do	132	129	1.02
September 8	....do	116	129	.899
June 24	Deep Creek one-half mile above mouth	1.1	4.8	.229
September 7	....do	2.68	4.8	.559
June 24	Nugget Creek at mouth	.8	2.7	.296
July 20	West Fork of Granite Creek 1½ miles above forks	27.9	41.9	.666
June 26	Granite Creek at mouth	190	138	1.38
July 20	East Fork of Granite Creek 1 mile above forks	25.2	45.6	.553
June 24	Barney Creek at mouth	2.2	.....	.....
September 9	Washington Creek ditch at intake	3.51	.....	.....
September 10	Broken Neck Creek at mouth	1.06	2.9	.366
June 23	Mogul Creek at mouth	67.2	64.4	1.04
September 6	....do	50.5	64.4	.784
June 21	Bryant Creek at summer trail crossing	16.0	21.4	.748
September 4	....do	18.9	21.4	.883
June 21	Rock Creek at bridge	1.41	7.3	.193
September 4	....do	2.19	7.3	.300

EAGLE DISTRICT.

GENERAL FEATURES.

The name Eagle district as used in this report denotes the area adjacent to the town of Eagle. The streams included in this area are Mission Creek, with its tributaries, and Yukon River at Eagle. The entire district has been topographically mapped, and considerable mining has been done within it.

The following list gives the location at which gaging stations were maintained or discharge measurements were made in the Eagle district in 1912. The relation of the streams is shown by indention.

Mission Creek above Excelsior Creek.
  Excelsior Creek at mouth.
  Wolf Creek at Swanson's dam.
  Wolf Creek at Road Crossing.
  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 very unsymmetrical basin between the Fortymile and Seventymile basins and the Yukon. The water of the creek comes almost entirely from the northern and eastern slope of Glacier Mountains, flowing northerly to join the main creek at the very northern edge of its watershed. The main creek flows north to its junction with Excelsior Creek, about 8 miles above its mouth, where it makes a sharp bend and flows nearly directly east to its confluence with the Yukon at Eagle. Wolf Creek joins Mission Creek about 4 miles and American Creek about 1 mile from the Yukon.

American Creek, the largest tributary of Mission Creek, rises in the high ridges bounding the extreme northern part of Fortymile River. It flows northeastward and is about 10 miles in length. Discovery Fork is the main branch of American Creek and joins it about 8 miles above the mouth. Above Marion Creek, a small feeder from the east, American Creek flows through a narrow V-shaped canyon; below Marion Creek the valley widens until it finally merges in the flats adjoining Mission Creek. The creek has a steep grade, especially near the head, the average in that portion where mining is carried on being about 125 feet to the mile. American Creek has been an important gold producer.

Daily discharge, in second-feet, of American Creek and Discovery Fork for 1912.

Day.	American Creek at claim "No. 8 above."[a] [Drainage area, 24.1 square miles.]					Discovery Fork below Star Gulch.[b] [Drainage area, 14.8 square miles.]				
	June.	July.	Aug.	Sept.	Oct.	May.	June.	July.	Aug.	Sept.
1	.....	5.9	20	11	11	.....	6.6	2.2	3.9	3.9
2	.....	4.4	20	11	11	.....	8.0	2.2	3.9	3.9
3	.....	4.4	20	11	11	.....	9.4	2.2	3.9	3.9
4	.....	3.4	16	14	11	.....	8.0	1.8	3.9	5.6
5	.....	3.4	20	14	11	.....	5.6	1.8	3.9	4.6
6	.....	2.4	20	17	11	.....	4.6	1.8	5.6	3.9
7	.....	2.0	108	19	11	.....	3.9	1.8	9.4	3.9
8	.....	1.6	53	19	11	.....	13	1.8	6.6	.....
9	.....	1.6	38	21	11	.....	9.4	1.4	5.6	.....
10	.....	1.3	38	25	11	.....	6.6	1.8	6.6	.....
11	.....	2.4	103	21	11	.....	6.6	2.2	26	.....
12	.....	26	77	21	11	.....	6.6	2.2	20	.....
13	18	22	53	17	9	.....	5.6	2.7	9.4	.....
14	18	12	48	17	9	.....	4.6	2.7	9.4	.....
15	34	5.9	38	17	9	.....	3.9	2.7	6.6	.....
16	26	4.4	34	17	9	.....	15	2.2	6.6	.....
17	22	3.4	25	25	9	.....	5.6	2.2	5.6	.....
18	18	2.4	25	29	.....	.....	4.6	2.2	5.6	.....
19	15	2.4	34	25	.....	.....	3.9	2.2	6.6	.....
20	15	2.0	25	25	.....	.....	3.9	2.7	6.6	.....
21	22	26	25	25	.....	.....	3.2	13	6.6	.....
22	26	39	25	25	.....	11	3.2	15	5.6	.....
23	22	37	25	21	.....	8.0	3.2	5.6	6.6	.....
24	18	24	21	21	.....	6.6	2.7	4.6	6.6	.....
25	18	20	21	17	.....	6.6	8.0	4.6	5.6	.....
26	18	20	17	17	.....	6.6	4.6	4.6	4.6	.....
27	15	20	17	14	.....	6.6	2.7	5.6	3.9	.....
28	12	16	17	14	.....	6.6	2.2	4.6	3.9	.....
29	9.7	16	17	14	.....	32	2.2	3.2	3.9	.....
30	7.4	20	14	11	.....	13	2.2	2.7	3.9	.....
31	.....	20	14	.....	.....	9.4	.....	3.9	3.9	.....
Mean	18.6	12.0	33.2	18.5	10.4	10.6	5.7	3.6	6.8	4.2
Mean per square mile	.772	.498	1.38	.767	.432	.716	.385	.243	.460	.284
Run-off (depth in inches on drainage area)	.52	.57	1.59	.86	.27	.27	.43	.28	.53	.07
Accuracy	B.	C.	C.	C.	B.	C.	C.	C.	C.	C.

[a] The channel shifted July 22 and August 7. The rating curve is fairly well defined below 25 second-feet.
[b] There were shifting channel conditions at this station. The results are probably accurate within 15 per cent.

Miscellaneous measurements in Mission Creek drainage basin in 1912.

Date.	Stream and locality.	Discharge.	Drainage area.	Discharge per square mile.
		Sec.-ft.	*Sq. mi.*	*Sec.-ft.*
June 21	Mission Creek above Excelsior Creek	89.8	93.1	0.965
September 4	....do	68.9	93.1	.740
June 21	Excelsior Creek at mouth	16.2	31.1	.521
September 4	....do	17.2	31.1	.553
June 19	Wolf Creek at Swanson's dam	9.6	19.5	.492
June 21	Wolf Creek at road crossing	10.8	28.4	.380
September 4	....do	9.7	28.4	.341
May 20	American Creek at United States pumping plant	88	67.3	1.31
May 22	....do	88	67.3	1.31
May 31	....do	79	67.3	1.17
June 19	....do	28	67.3	.416
August 1	....do	32	67.3	.475
September 4	....do	28	67.3	.416

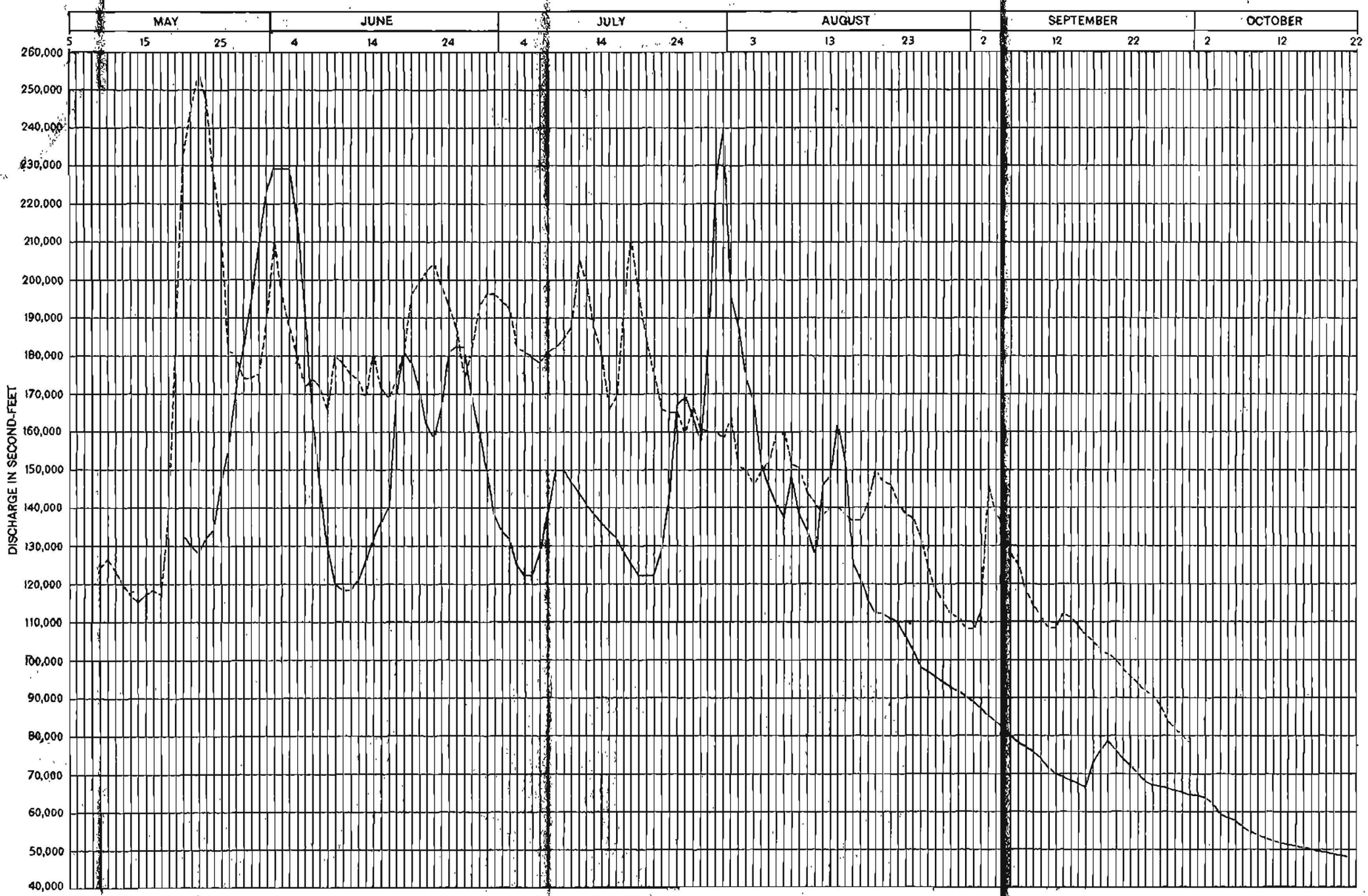
YUKON RIVER AT EAGLE.

The recording of the discharge of Yukon River at Eagle, which was begun in May, 1911, was continued during the summer of 1912. In the Yukon drainage basin the winter season is long and the cold intense; it is called the "closed" season because the river is closed for navigation. During this period all precipitation remains in the form of snow, and the ground freezes deep, so the source of stream flow is limited to open springs and lake storage. Consequently the discharge during the closed season is very small, and far the greatest proportion of the run-off occurs during the open season or that portion of the year when the river is open for navigation. This season usually extends from about May 20 to October 20. The snow begins to melt the latter part of April. About May 10 a stage is reached at which the ice begins to break up and move, and it is usually about ten days before the stream is free of the floating ice.

The characteristic distribution of flow in the Yukon during the open season appears to be a high run-off during the first of the open season, caused by the melting snows, the discharge usually reaching a maximum late in May or early in June, then gradually decreasing through the summer as the supply of snow is exhausted. With the approach of the frozen season it falls rapidly. The precipitation during the summer causes wide fluctuations in the flow, but does not seriously affect the general trend as described. The winter of 1911–12 in the Yukon basin was peculiar in its exceptionally light snowfall. Consequently this source of stream flow was less noticeable in its influence during 1912 than in 1911, as is shown by the hydrographs for these two seasons. (See Pl. IX.) In the summer of 1912 the maximum discharge occurred the last of July.

The rating of the Yukon at Eagle is based on float measurements made by timing the passage of ice cakes or driftwood over a 500-foot run and locating them by range line and angle. The cross section at the place of measurement, which is about 1,400 feet in width, was obtained by sounding through the ice. In September, 1912, an accurate float measurement was made by means of bottle floats weighted with sand and carrying flags. These were dropped at intervals of about 75 feet across the stream and their passage timed over the run. Determinations were also made of the coefficient to be applied to surface velocities to reduce to mean velocities in the section. The results indicated a coefficient of 0.92, which is somewhat higher than in most streams. The record for 1911 has been recomputed, using this coefficient.

Hydrographs of the daily flow of Yukon River at Eagle for the season of 1911 and 1912 are given in Plate IX, and tables follow, giving the mean monthly discharge, the run-off per square mile, the run-off from the drainage area in depth in inches, and the maximum and minimum discharges for the month, for 1911 and 1912.



HYDROGRAPH SHOWING DAILY DISCHARGE OF YUKON RIVER, 1911 (BROKEN LINE) AND 191[illegible] (SOLID LINE).

Monthly discharge of Yukon River at Eagle for 1911 and 1912.

[Drainage area, 122,000 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1911.					
May 9–31	254,000	115,000	169,000	1.39	1.19
June	210,000	166,000	184,000	1.51	1.68
July	211,000	158,000	178,000	1.46	1.68
August	160,000	108,000	139,000	1.14	1.31
September	146,000	78,000	106,000	.869	.97
The period, 145 days	254,000	78,000	155,000	1.27	6.83
1912.					
May 20–31	223,000	128,000	161,000	1.32	.59
June	229,000	118,000	160,000	1.32	1.47
July	240,000	122,000	147,000	1.20	1.38
August	188,000	90,500	127,000	1.04	1.20
September	89,000	64,500	73,600	.603	.67
October 1–21	64,000	47,500	53,900	.442	.35
The period, 155 days	240,000	47,500	120,000	.984	5.66

Daily discharge, in second-feet, of Yukon River at Eagle for 1912.[a]

[Drainage area, 122,000 square miles.]

Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	229,000	134,000	188,000	89,000	64,000
2	.....	229,000	132,000	174,000	87,300	63,500
3	.....	229,000	125,000	168,000	85,500	62,000
4	.....	217,000	122,000	152,000	84,000	59,000
5	.....	193,000	122,000	146,000	82,000	58,000
6	.....	165,000	128,000	141,000	80,000	57,000
7	.....	146,000	138,000	137,000	78,000	56,000
8	.....	129,000	150,000	148,000	77,000	55,000
9	.....	120,000	150,000	138,000	76,000	54,000
10	.....	118,000	147,000	134,000	74,000	53,000
11	.....	118,000	144,000	128,000	72,000	52,500
12	.....	121,000	141,000	146,000	70,000	52,000
13	.....	126,000	138,000	148,000	69,000	51,500
14	.....	132,000	136,000	162,000	68,000	51,000
15	.....	136,000	134,000	152,000	67,100	50,500
16	.....	140,000	132,000	125,000	66,200	50,000
17	.....	169,000	128,000	122,000	73,000	49,500
18	.....	181,000	125,000	115,000	76,000	49,000
19	.....	178,000	122,000	112,000	78,500	48,500
20	133,000	171,000	122,000	112,000	76,000	48,000
21	130,000	162,000	122,000	111,000	74,000	47,500
22	128,000	158,000	128,000	110,000	72,000	.....
23	132,000	166,000	143,000	106,000	70,000	.....
24	134,000	181,000	167,000	103,000	68,000	.....
25	146,000	182,000	169,000	98,300	67,000	.....
26	155,000	182,000	164,000	97,000	66,500	.....
27	172,000	169,000	158,000	95,500	66,000	.....
28	182,000	160,000	182,000	94,500	65,500	.....
29	194,000	150,000	226,000	93,000	65,000	.....
30	208,000	138,000	240,000	92,000	64,500	.....
31	223,000	.....	196,000	90,500	.....	.....
Mean	161,000	160,000	147,000	127,000	73,600	53,900
Mean per square mile	1.32	1.32	1.20	1.04	.603	.442
Run-off (depth in inches on drainage area)	.59	1.47	1.38	1.20	.67	.35
Accuracy	A.	A.	A.	A.	A.	A.

[a] Rating curve well defined for all stages.

CIRCLE PRECINCT.

GENERAL FEATURES.

The area north of the Yukon-Tanana divide between longitude 143° 40′ and 146° 50′ is known as the Birch Creek district of the Circle precinct. 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, and 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.

The following list gives the locations at which gaging stations were maintained or discharge measurements made in 1912 in the Circle district.

Birch Creek drainage basin:

- Ptarmigan Creek at mouth.
- Birch Creek above Twelvemile Creek.
- Birch Creek below Twelvemile Creek.
- Birch Creek below Great Unknown Creek.
- Birch Creek above Sheep Creek.
- Birch Creek at Fourteenmile House.
- Eagle Creek at mouth.
- Golddust Creek, 3 miles above mouth.
- Golddust Creek at mouth.
- Fish Creek at mouth.
- Butte Creek at mouth.
- Bear Creek at mouth.
- Twelvemile Creek below South Fork.
- North Fork of Twelvemile Creek at mouth.
- Harrington Fork above Crooked Creek.
- Crooked Creek at mouth.
- Great Unknown Creek at mouth.
- Acme Creek, 2 miles above mouth.
- Clums Fork below Munson Creek.

Birch Creek drainage basin—Continued.
Clums Fork below Bear Creek.
Lawson Creek at mouth.
Bear Creek at mouth.
Buckley Bar Creek at mouth.
Sheep Creek at mouth.
Porcupine Creek below ditch intake.
Porcupine Creek below Bonanza Creek.
Crooked Creek at Central House.
Bonanza Creek below ditch intake.
Independence Creek at claim "No. 9 above."
Miller Creek at mouth.
Boulder Creek at road crossing.
Deadwood Creek above Switch Creek.
Circle Hot Springs.
Portage Creek, 4 miles above Medicine Lake.
Porcupine ditch at intake.
Bonanza ditch at intake.
Bonanza ditch below junction with Porcupine branch.
Bonanza ditch at outlet.

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. Its basin is extremely unsymmetrical in outline, the drainage coming almost entirely from the south and west through a complex system of watercourses, whose headwaters interlock with those of Chena and Chatanika rivers.

Birch Creek is formed by the junction of Eagle and Ptarmigan creeks and 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. It then receives the waters of Harrington Fork and runs eastward for about 45 miles to its confluence with the South Fork, where it makes a sharp turn to the north. About 12 miles farther on it leaves the mountainous country and enters the lowlands of the Yukon, through which it sluggishly meanders for over 100 miles, roughly paralleling the Yukon at a distance of 10 to 20 miles. Some of the tributaries from the right in downstream order are Fish, Bear, Twelvemile, Harrington Fork, Malburn, Acme, Clums Fork, McLean, Wolf, Sheep, and South Fork. From the left in downstream order they are Golddust, Butte, Fryingpan, Great Unknown, Harrison, Buckley Bar, Crooked, and Preacher creeks.

Monthly discharge of Birch Creek at Fourteenmile House for 1908 to 1912.

[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
September 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	1,800	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
October 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	1,100	2,500	1.16	1.29
July	3,400	551	1,430	.665	.77
August	1,880	432	950	.442	.51
September	3,280	1,040	1,620	.753	.84
October 1–6	1,140	1,080	1,090	.507	.11
The period, 147 days	6,620	432	2,010	.935	5.10
1911.					
May 15–31	15,300	4,120	8,190	3.81	2.41
June	9,490	1,010	3,740	1.74	1.94
July	3,260	262	987	.459	.53
August	2,060	208	609	.283	.33
September	587	418	501	.233	.26
October 1–23	614	198	379	.176	.15
The period, 162 days	15,300	198	2,050	.953	5.62
1912.					
May 10–31	5,380	1,090	2,350	1.09	.89
June	14,100	1,400	4,650	2.16	2.41
July	1,510	450	611	.284	.33
August	3,460	400	1,110	.516	.59
September	4,000	960	1,710	.795	.89
October 1–21	1,290	350	924	.430	.34
The period, 165 days	14,100	350	1,910	.888	5.45

Daily discharge, in second-feet, of Birch Creek for 1912.

Day.	Birch Creek below Twelvemile Creek.[a] (Drainage area, 141 square miles.)					Birch Creek below Great Unknown Creek.[b] (Drainage area, 376 square miles.)				
	June.	July.	Aug.	Sept.	Oct.	June.	July.	Aug.	Sept.	Oct.
1	1,060	96	47	91	132	.....	218	125	234	272
2	1,060	98	44	113	132	.....	186	113	272	272
3	835	91	41	130	116	.....	253	113	300	253
4	460	67	49	166	105	.....	186	113	344	231
5	322	61	47	169	108	355	153	113	355	227
6	248	49	47	150	110	378	138	110	320	234
7	172	47	144	138	110	345	130	186	292	218
8	144	44	186	132	91	313	120	400	272	218
9	142	41	127	132	96	378	113	272	253	201
10	121	38	100	121	91	355	106	218	234	201
11	90	42	222	113	86	292	110	272	231	178
12	183	41	323	108	84	424	113	626	218	170
13	322	38	233	110	86	759	107	524	210	153
14	284	46	176	91	.....	652	112	422	201	128
15	364	47	144	110	.....	800	116	320	227	132
16	695	42	121	124	.....	900	113	218	272	125
17	542	44	100	183	.....	850	113	201	448	120
18	600	44	91	284	.....	900	120	201	626	116
19	729	44	86	248	.....	1,740	120	172	599	.....
20	410	44	86	276	.....	985	120	170	610	.....
21	343	42	82	272	.....	705	116	153	500	.....
22	513	41	78	240	.....	814	113	148	400	.....
23	1,410	42	78	203	.....	2,260	112	153	340	.....
24	1,060	44	78	183	.....	2,520	110	162	320	.....
25	738	41	80	166	.....	2,200	110	172	310	.....
26	417	51	91	144	.....	1,350	112	240	300	.....
27	302	54	108	144	.....	759	116	300	290	.....
28	218	61	103	141	.....	547	138	290	280	.....
29	157	63	98	138	.....	378	135	280	270	.....
30	121	61	88	138	.....	292	132	272	272	.....
31	.....	54	88	.....	.....	.....	128	253	.....	.....
Mean	469	52.2	109	159	104	856	131	236	327	192
Mean per square mile	3.33	.370	.773	1.13	.738	2.28	.348	.628	.870	.511
Run-off (depth in inches on drainage area)	3.72	.43	.89	1.26	.36	2.20	.40	.72	.97	.34
Accuracy	C.	A.	A.	A.	A.	D.	A.	B.	B.	B.

[a] The gage was washed out by high water on June 25. The discharges previous to that date are rather uncertain. Since that date the discharges are based on a rating curve that is well defined below 200 second-feet.

[b] Discharges are well defined between 120 and 400 second-feet.

Daily discharge, in second-feet, of Birch Creek for 1912.

Day.	Birch Creek above Sheep Creek.[a] [Drainage area, 873 square miles.]					Birch Creek at Fourteenmile House.[b] [Drainage area, 2,150 square miles.]					
	May.	June.	July.	Aug.	Sept.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	3,320	605	236	535	.....	3,460	1,510	450	960	1,290
2	.....	6,370	465	230	755	.....	8,070	1,190	450	1,090	1,290
3	.....	4,440	535	214	755	.....	9,560	1,190	425	1,400	1,190
4	.....	3,060	465	214	755	.....	7,360	1,290	425	1,290	1,190
5	.....	1,780	382	203	755	.....	4,570	920	400	1,290	1,190
6	.....	1,190	316	203	755	.....	2,950	725	400	1,290	1,090
7	.....	920	258	535	680	.....	2,180	690	450	1,190	1,040
8	1,470	755	225	1,010	718	.....	1,630	620	1,190	1,190	1,040
9	1,190	835	220	755	605	.....	1,400	560	1,630	1,190	1,040
10	1,470	1,010	203	570	605	1,400	1,760	560	1,510	1,090	1,000
11	1,280	795	225	795	570	1,510	1,760	450	1,190	1,090	1,000
12	1,470	680	225	1,570	535	1,760	1,400	450	2,780	1,040	1,000
13	1,890	2,220	225	1,200	500	2,040	2,470	475	3,460	1,000	960
14	2,810	1,780	220	1,000	500	3,120	3,460	450	2,180	1,000	920
15	1,890	2,200	236	800	605	3,120	2,780	450	1,630	960	840
16	2,450	2,500	225	600	680	3,460	2,780	500	1,400	960	760
17	2,450	2,400	214	535	755	3,820	4,570	450	1,400	1,090	690
18	1,780	3,000	220	500	1,370	3,120	3,460	450	1,190	1,900	620
19	1,280	4,020	242	465	1,470	2,320	3,460	450	1,090	2,320	500
20	1,140	2,200	242	420	1,700	1,900	5,800	475	1,000	2,470	400
21	1,140	1,570	252	376	2,000	1,630	4,190	450	840	3,460	350
22	1,100	2,000	258	364	2,690	1,400	2,950	500	840	4,000	
23	1,570	5,020	242	340	2,450	1,630	3,820	450	800	3,460	.....
24	1,280	8,100	236	340	.....	2,470	9,060	450	800	2,950	.....
25	795	7,940	214	376	.....	1,900	14,100	450	760	2,780	.....
26	642	4,440	198	406	.....	1,290	13,000	450	760	2,320	.....
27	680	2,330	220	642	.....	1,190	8,070	450	760	2,040	.....
28	680	1,470	304	718	.....	1,090	4,190	450	1,000	1,630	.....
29	2,810	1,100	340	680	.....	1,630	3,120	500	1,090	1,510	.....
30	2,930	680	316	570	.....	5,380	2,180	450	1,000	1,400	.....
31	1,670	.....	274	535	.....	4,570	.....	475	960	.....	.....
Mean	1,580	2,670	284	561	989	2,350	4,650	611	1,110	1,710	924
Mean per square mile	1.81	3.06	.325	.643	1.13	1.09	2.16	.284	.516	.795	.430
Run-off (depth in inches on drainage area)	1.62	3.41	.37	.74	.97	.89	2.41	.33	.59	.89	.34
Accuracy	A.	B.	A.	A.	A.	A.	A.	A.	A.	A.	A.

[a] Discharges are well defined below 4,000 second-feet.
[b] Discharges are well defined below 2,000 second-feet.

Daily discharge, in second-feet, of Great Unknown Creek, Clums Fork, and Lawson Creek for 1912.

Day.	Great Unknown Creek at mouth.[a] [Drainage area, 41.2 square miles.]				Clums Fork below Munson Creek.[b] [Drainage area, 46.4 square miles.]			Lawson Creek at mouth.[c] [Drainage area, 21.6 square miles.]		
	June.	July.	Aug.	Sept.	July.	Aug.	Sept.	July.	Aug.	Sept.
1	.....	.....	15	20	34	28	26	17.2	15	14.3
2	.....	.....	10.1	25	29	27	25	15.4	14	13.8
3	.....	22	10	30	26	26	26	14.1	14	13.8
4	.....	16.3	10	40	26	25	26	13.8	13.6	14.1
5	.....	13.6	10.1	41	25	24	25	13.3	13.3	13.8
6	.....	12	10	36	25	23	26	12.9	12.9	14.1
7	.....	11	104	31	26	46	25	13.3	27	13.6
8	28	10	81	29	25	33	25	13.3	18.1	13.6
9	33	9.2	26	28	24	29	26	13.3	16.3	14.1
10	40	9.2	20	27	48	28	26	35	15.9	13.8
11	40	9.0	41	26	28	52	25	20	27	13.6
12	90	9.2	38	22	24	46	25	15.4	25	13.8
13	135	10	35	24	24	42	25	14.1	23	13.6
14	120	10.1	32	26	29	38	24	16.8	21	13.3
15	110	10	29	26	25	36	25	15.4	19	14.3
16	100	10.1	26	29	25	32	28	14.6	17	15.4
17	90	10	22	109	24	28	34	13.8	15.9	15.9
18	85	10	21	65	27	28	37	14.9	16.8	16.3
19	323	10.1	20	52	25	26	34	13.8	15.9	16.3
20	195	10	19.5	.....	25	24	66	13.8	14.6	27
21	109	10	19	.....	26	23	64	14.3	14.1	26
22	.....	10	18	.....	25	25	52	13.8	15.9	20
23	.....	10.1	17.5	.....	24	26	46	13.8	16.8	20
24	.....	10	17.5	.....	24	26	42	13.3	15.0	20
25	.....	10	17	.....	24	25	.....	12.9	14.1	.....
26	.....	10.1	17	.....	24	26	.....	13.6	14.9	.....
27	.....	12	25	.....	37	28	.....	18.1	14.6	.....
28	.....	20	25	.....	34	27	.....	18.1	13.8	.....
29	.....	30	20	.....	32	26	.....	18	13.8	.....
30	.....	32	17	.....	30	26	.....	17	14.3	.....
31	.....	26	17	.....	29	25	.....	16	14.1	.....
Mean	106	13.2	25.5	36.1	27.5	29.8	32.6	15.6	16.7	16.0
Mean per square mile	2.58	.320	.619	.876	.593	.642	.703	.722	.773	.741
Run-off (depth in inches on drainage area)	1.34	.35	.71	.62	.68	.74	.63	.83	.89	.66
Accuracy	D.	B.	C.	C.	B.	B.	C.	C.	B.	B.

[a] Gage was washed out June 22. Discharges previous to that date are only approximate. A new gage was installed July 3. The discharge rating curve for the new gage is fairly well defined below 60 second-feet.
[b] Discharges are fairly well defined below 40 second-feet.
[c] Discharges are fairly well defined below 20 second-feet.

Daily discharge, in second-feet, of Buckley Bar Creek and Sheep Creek for 1912.

Day.	Sheep Creek at mouth. [Drainage area, 46.7 square miles.]				Buckley Bar Creek at mouth. [Drainage area, 10.6 square miles.]				
	May.	June.	July.	Aug.	May.	June.	July.	Aug.	Sept.
1						22	2.6	0.61	6.3
2				6.8		39	2.2	.60	8.0
3						22	1.7	.59	7.8
4		67				13.5	1.4	.57	7.5
5				8.3		5.0	1.2	.55	7.2
6						3.6	.90	1.0	5.9
7				179		4.0	.82	8.0	5.0
8		26				4.6	.70	7.8	5.0
9						5.2	.67	5.7	7.2
10						3.4	.75	9.0	6.5
11						1.5	.62	13.1	6.0
12						3.4	.69	33	5.5
13						4.2	.66	16.0	5.0
14						4.0	.63	10.0	6.0
15						6.0	.67	7.0	6.9
16	84					12.0	.59	5.0	7.0
17						17.0	.63	5.0	7.0
18				33		12.0	1.0	4.6	7.5
19		142		31		22	1.4	4.0	16.0
20	84		9.8			12.0	1.2	3.4	25
21		134			2.6	4.4	1.2	3.2	34
22	67				2.0	7.8	1.1	2.9	43
23					5.9	12.0	1.1	2.8	
24			9.8		3.6	30	1.0	2.6	
25				18.6	2.8	41	.98	3.9	
26			7.5		2.0	26	.86	5.2	
27					3.2	7.8	.75	6.6	
28	25				4.4	5.5	.67	5.2	
29	193	60			34	3.9	.65	2.9	
30	124				17.0	3.6	.63	2.8	
31			118	22	9.9		.62	2.6	
Mean					7.95	1.19	.990	5.68	10.7
Mean per square mile					.750	.112	.093	.536	1.01
Run-off (depth in inches on drainage area)					.31	.12	.11	.62	.83
Accuracy					B.	B.	B.	B.	B.

NOTE.—The above discharges are fairly well defined for all stages.

Miscellaneous measurements in Birch Creek drainage basin, 1912.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-feet.*	*Sec.-feet.*
June 6	Ptarmigan Creek at mouth	19	29	1.53
July 18	do	19	5.0	.26
Aug. 18	do	19	15.6	.82
July 18	Birch Creek above Twelvemile Creek	88	27	.31
June 6	Eagle Creek at mouth	15.5	17.0	1.09
July 5	Golddust Creek 3 miles above mouth	10.0	5.0	.50
July 18	Golddust Creek at mouth	13.6	6.9	.51
Aug. 18	do	13.6	9.3	.68
July 18	Fish Creek at mouth	6.0	.52	.087
Aug. 18	do	6.0	3.1	.52
July 18	Butte Creek at mouth	9.2	5.5	.60
Aug. 18	do	9.2	6.2	.67
June 6	Bear Creek at mouth	12.4	14.0	1.13
July 18	do	12.4	2.5	.20
Aug. 18	do	12.4	7.2	.58
June 8	Twelvemile Creek below South Fork	23	14.3	.62
Aug. 17	do	23	6.8	.30
June 8	North Fork of Twelvemile Creek at mouth	22.9	23	1.00
Aug. 17	do	22.9	7.7	.34
July 19	Harrington Fork above Crooked Creek	44.7	13.2	.30
Do	Crooked Creek at mouth (tributary of Harrington Fork).	33.3	6.5	.20
July 3	Acme Creek 2 miles above mouth	27.7	7.0	.25
Aug. 25	do	27.7	3.8	.14
July 3	Clums Fork below Bear Creek	106	70	.66
Aug. 25	do	106	62	.58
July 3	Bear Creek at mouth (tributary of Clums Fork)	34.7	32	.92
Aug. 25	do	34.7	30	.87

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 from the west about 2 miles below this junction. 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 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.

Portage Creek rises in the divide between Birch and Crooked creeks, about 10 miles east of Deadwood Creek. It flows northeast for about 8 miles to Medicine Lake.

Daily discharge, in second-feet, of Porcupine Creek, below ditch intake and below Bonanza Creek for 1912.

Day	Porcupine Creek below ditch intake.[a] [Drainage area, 17.8 square miles.]				Porcupine Creek below Bonanza Creek.[b] [Drainage area, 39.9 square miles.]			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1	.....	0	0	4.4	.....	3.0	0.8	13.0
2	75	0	0	15.4	142	3.0	.8	23
3	55	0	0	14.3	142	2.6	.8	30
4	35	0	0	10.7	67	2.1	.8	26
5	12.8	0	0	8.0	7.6	1.7	.8	19.8
6	2.9	0	0	4.2	5.2	1.5	.8	15.5
7	1.6	0	0	2.9	4.4	.8	.8	12.3
8	0	0	0	1.4	3.5	.8	.8	9.0
9	0	0	0	1.6	2.9	.8	.8	5.8
10	0	0	0	1.6	2.9	.8	.8	7.0
11	0	0	27	.6	2.0	.8	39	5.7
12	5.1	0	22	.3	2.9	.8	30	4.4
13	27	0	13.5	0	29	.8	19.8	3.1
14	34	0	5.6	0	34	.8	13.4	1.9
15	71	0	0	0	29	.8	7.0	16
16	121	0	0	27	150	.7	3.0	30
17	56	0	0	22	83	.8	2.4	46
18	34	0	0	26	176	.8	1.9	61
19	60	0	0	18.3	67	.8	1.3	50
20	56	0	0	15.4	19.6	.8	.8	39
21	15.4	0	0	.....	11.2	.8	.8	.....
22	56	0	0	.....	83	.8	.8	.....
23	214	0	0	.....	297	.8	.8	.....
24	295	0	0	.....	320	.8	.8	.....
25	228	0	0	.....	251	.8	.8	.....
26	40	0	0	.....	133	.8	.8	.....
27	18.3	0	0	.....	81	.8	1.9	.....
28	3.2	0	0	.....	26	.8	3.0	.....
29	0	0	0	.....	7.0	.8	3.0	.....
30	0	0	0	.....	3.8	.8	3.0	.....
31	.....	0	0	.....	.....	.8	3.0	.....
Mean	52.3	0	2.19	8.70	75.3	1.09	4.69	20.9
Accuracy	.....	.....	.....	.....	D.	A.	B.	B.

[a] The discharge rating curve for this station is fairly well defined below 75 second-feet. To obtain the natural flow of Porcupine Creek below ditch intake add the flow of Porcupine ditch at intake.

[b] Channel shifted considerably on June 23 and 24. New rating applied after June 23. Discharges well defined below 15 second-feet.

Daily discharge, in second-feet, of Crooked Creek at Central House for 1912.

[Drainage area, 161 square miles.]

Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	546	55	7.5	55	69
2	.....	635	44	8.6	98	64
3	.....	503	41	8.6	118	55
4	.....	293	39	8.6	132	48
5	.....	164	30	8.6	106	41
6	.....	106	26	8.6	113	41
7	.....	89	19.7	12.2	106	39
8	.....	52	17.8	48	89	41
9	30	48	14.5	41	72	41
10	26	48	17.8	48	64	36
		30				
11	32	36	17.8	52	69	30
12	52		14.5	180	72	30
13	82	132	13.6	173	72	41
14	187	164	12.2	113	64	41
15	118	147	9.8	82	64	55
16	154	590	9.8	64	72	55
17	216	334	9.8	55	164	55
18	209	198	9.8	41	293	55
19	216	397	8.6	39	216	.....
20	154	254	9.3	41	209	.....
21	118	147	8.6	36	224	.....
22	141	187	8.6	32	235	.....
23	214	726	9.3	30	173	.....
24	187	916	8.6	30	118	.....
25	154	868	8.6	30	106	.....
26	124	635	9.8	30	89	.....
27	106	397	8.6	48	72	.....
28	154	254	8.6	52	72	.....
29	293	180	9.3	48	70	.....
30	214	82	8.6	41	70	.....
31	198	.....	7.5	41	.....	.....
Mean	147	305	16.6	47.0	116	46.5
Mean per square mile	.913	1.89	.103	.292	.720	.289
Run-off (depth in inches on drainage area)	.78	2.11	.12	.34	.80	.19
Accuracy	A.	B.	A.	A.	A.	A.

NOTE.—The rating curve for the above discharges is well defined below 300 second-feet.

Daily discharge, in second-feet, of Bonanza and Miller creeks for 1912.

Day.	Bonanza Creek below ditch intake.[a] [Drainage area, 7.9 square miles.]					Miller Creek at mouth.[b] [Drainage area, 105 square miles.]		
	May.	June.	July.	Aug.	Sept.	June.	July.	Aug.
1	.....	.....	0.4	0.3	0.3	.....	2.5	.....
2	.....	51	.4	.3	.4	.....	14.7	.....
3	.....	44	.3	.3	.4	.....	4.1	.....
4	.....	5.3	.3	.3	.4	38	3.0	.....
5	.....	.6	.3	.3	.4	23	3.0	.....
6	.....	.5	.3	.3	.4	14.7	2.5	.....
7	.....	.4	.3	.3	.3	12.3	2.0	.....
8	.....	.4	.3	.3	.3	10.3	4.1	.....
9	.....	.5	.3	.3	.3	8.3	3.0	.....
10	.....	.4	.3	.3	.3	6.8	3.0	.....
11	.....	.4	.3	2.4	.3	6.8	2.5	.....
12	.....	.6	.3	.6	.3	34	2.5	.....
13	.....	1.3	.3	.5	.3	20	2.0	.....
14	.....	2.9	.3	.7	.3	12.3	2.0	.....
15	.....	25	.3	.4	.3	76	2.0	.....

[a] New rating used after June 22. Discharges are only approximate. To obtain natural flow past this station add the discharge of Bonanza ditch at intake.

[b] Station abandoned July 15 because of shifting channel. Discharges are only approximate.

Daily discharge, in second-feet, of Bonanza and Miller creeks for 1912—Continued.

Day.	Bonanza Creek below ditch intake. [Drainage area, 7.9 square miles.]					Miller Creek at mouth. [Drainage area, 105 square miles.]		
	May.	June.	July.	Aug.	Sept.	June.	July.	Aug.
16		45	0.3	0.3	0.3	38		
17		1.2	.3	.3	.5	23		
18		.8	.3	.3	3.7	23		
19		30	.3	.3	1.6	30		
20		1.9	.3	.3	2.4	14.7		
21		.6	.3	.3	11	38		
22		19	.3	.3		65		
23		90	.3	.3		87		
24		46	.3	.3		50		
25		44	.3	.3		38		
26		26	.3	.3		23		
27		12	.3	.4		20		
28		12	.3	.4		17.1		
29		1.6	.3	.4		12.3		
30		.4	.3	.4		5.2		
31			.3	.3				
Mean		16.0	.31	.41	1.17	24.9	3.53	
Mean per square mile						2.37	.336	
Run-off (depth in inches on drainage area)						2.38	.19	
Accuracy		D.	D.	D.	D.	D.	D.	

Daily discharge, in second-feet, of Deadwood and Portage creeks for 1912.

Day.	Deadwood Creek above Switch Creek.[a] [Drainage area, 21.3 square miles.]						Portage Creek 4 miles above Medicine Lake.[b] [Drainage area, 10.9 square miles.]				
	May.	June.	July.	Aug.	Sept.	Oct.	May.	June.	July.	Aug.	Sept.
1		46	7.7	3.0	16.0	11.2		17.3	2.8	0.32	2.8
2		65	6.8	3.0	15	11.2		22	1.2	.30	6.3
3		54	5.9	3.0	15	10.3		17.3	1.2	.30	5.1
4		40	5.3	3.0	14	10.3		7.4	1.2	.37	4.2
5		34	5.3	5.0	13	10.3		8.8	1.2	.37	4.2
6		20	3.8	7.0	13	9.0		6.3	.96	.30	5.1
7		5.2	3.3	9.4	12	9.0		4.2	.78	8.8	2.8
8		5.2	3.3	10.8	11.2	9.0		2.8	.78	17.3	2.8
9		6.8	3.0	7.7	10	9.0		2.8	.60	6.3	5.1
10		6.8	3.0	12.0	9.0	7.7		2.0	.48	3.5	5.1
11		5.8	3.0	17.0	9.0	7.7		1.2	.39	41	4.2
12		6.8	3.0	18.5	11.2	9.0		2.0	.60	22	
13		15.6	3.0	13.6	10.3	9.0		6.3	.48	8.8	
14		10.9	3.0	12.2	11.2			4.2	.53	8.8	
15		10.9	3.0	10.3	9.0			6.3	.48	6.3	
16		32	3.0	9.0	10			12.2	.44	4.2	
17	29	15.6	3.0	7.7	16.0			17.3	.48	4.2	
18	21	10.9	3.0	6.8	20			12.2	.53	2.8	
19	19.8	26	3.0	5.9	21			22	.60	2.4	
20	17.2	15.6	3.0	5.9	21			12.2	.86	2.0	
21	13.8	10.9	3.0	5.9	21			6.3	.78	2.0	
22	14.7	38	3.0	5.3	18.5			47	.78	2.0	
23	29	70	3.5	5.3	16			55	.60	2.0	
24	16.4	50	3.8	5.3	14			47	.60	2.0	
25	12.0	44	3.3	5.3	13			41	.60	1.6	
26	16.4	38	26	5.3	13			34	.68	1.2	
27	12.7	29	3.5	5.3	12.2			17.3	.68	1.6	
28	17.2	20	3.0	6.2	11.2			4.2	.78	1.7	
29	37	11.2	3.0	6.8	11.2			1.2	.60	1.7	
30	29	11.2	3.0	7.7	11.2		21	.78	.48	1.6	
31	19.8		3.0	6.8			12.2		.39	1.6	
Mean	20.3	25.2	4.37	7.61	13.6	9.44	16.6	14.7	.76	5.14	4.34
Mean per square mile	.953	1.18	.205	.357	.638	.443	1.52	1.35	.070	.472	.398
Run-off (depth in inches on drainage area)	.53	1.32	.24	.41	.71	.21	.11	1.51	.08	.54	.16
Accuracy	B.	D.	B.	B.	B.	B.	B.	B.	B.	B.	B.

[a] From June 1 to 27 the discharges were applied indirectly because of shifting channel.
[b] Discharges are fairly accurate below 40 second-feet.

Daily discharge, in second-feet, of Porcupine ditch and Bonanza ditch at intake for 1912.

Day.	Porcupine ditch at intake.				Bonanza ditch at intake.[a]			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1	.....	7.8	1.9	10.0	.....	4.6	3.2	10.0
2	.....	6.1	1.8	12.5	20	4.0	3.2	10.5
3	.....	4.8	1.6	10.5	19.1	3.7	3.1	13.3
4	11.2	4.0	1.6	11.8	27	3.6	3.2	14.7
5	12.0	3.6	1.6	13.0	17.6	3.3	3.2	14.0
6	13.0	2.7	1.5	13.0	9.5	3.2	3.3	11.8
7	10.5	2.3	5.7	13.0	6.1	3.2	5.3	10.0
8	10.5	2.0	14.4	13.0	4.5	3.0	5.2	9.1
9	10.5	1.9	10.5	13.0	8.0	3.0	4.7	8.9
10	7.8	1.7	6.5	13.0	4.1	3.0	4.7	9.1
11	6.5	1.7	8.2	13.0	3.4	3.0	16.4	8.3
12	10.0	1.6	13.0	13.0	11.8	3.0	30	8.6
13	13.0	1.6	14.4	12.0	21	2.9	22	8.3
14	13.0	1.7	15.8	13.0	20	3.0	12.5	7.5
15	9.4	1.6	14.1	13.6	16.2	2.9	9.4	7.9
16	0	1.6	11.0	13.0	26	2.8	8.1	10.8
17	7.2	1.6	8.7	10.5	33	2.9	7.1	20
18	15.8	1.6	6.9	11.8	17.3	2.9	6.5	21
19	11.0	1.6	6.1	13.0	15.6	2.9	6.1	20
20	14.4	1.6	4.7	13.0	17.3	2.9	5.7	25
21	18.8	1.7	4.3	13.0	15.1	3.0	5.2	7.7
22	17.3	1.7	3.9	.....	18.6	3.0	4.9	.....
23	0	1.7	2.3	.....	11.8	3.0	5.7	.....
24	0	1.7	3.6	.....	8.3	3.1	6.5	.....
25	0	1.7	4.0	.....	8.3	3.1	6.3	.....
26	0	2.5	4.3	.....	9.4	3.3	7.3	.....
27	18.8	2.9	8.2	.....	7.1	3.2	10.5	.....
28	18.8	2.9	10.5	.....	4.3	3.3	11.5	.....
29	16.1	2.5	10.5	.....	6.3	3.2	9.1	.....
30	10.0	2.1	10.0	.....	5.3	3.2	8.1	.....
31	.....	2.1	9.4	.....	.....	3.2	7.1	.....
Mean	10.2	2.47	7.13	12.5	13.5	3.17	7.91	12.2
Accuracy	A.	A.	A.	A.	C.	B.	B.	B.

[a] New rating curve used after June 17 because of shifting channel. It is well defined below 15 second-feet.

Daily discharge, in second-feet, of Bonanza ditch for 1912.

Day.	Bonanza ditch below junction with Porcupine branch.[a]				Bonanza ditch at outlet.			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1	.....	12.0	4.8	15.7	.....	14.1	4.1	13.0
2	23	10.1	4.7	19.2	39	12.0	3.9	18.2
3	27	9.0	4.7	22	40	9.4	3.8	20
4	29	8.0	4.8	24	38	7.4	3.8	21
5	31	6.8	4.7	23	36	6.4	3.5	21
6	25	6.1	4.8	22	29	5.4	3.4	19.7
7	19.2	5.7	9.0	20	24	4.4	3.8	19.1
8	15.4	5.3	6.8	19.6	18.8	3.4	6.6	18.5
9	22	5.1	13.1	19.6	24	3.1	10.5	18.5
10	13.4	4.8	10.6	19.6	16.5	4.2	9.1	18.8
11	11.1	5.0	24	13.7	12.8	3.4	15.2	18.2
12	23	4.8	30	18.8	20	3.1	25	16.5
13	35	4.7	30	18.5	28	3.1	13.0	18.2
14	34	4.7	22	16.8	31	3.1	10.5	16.5
15	30	4.7	14.2	18.1	37	3.1	9.4	17.1
16	27	4.6	14.2	18.8	39	1.8	17.9	20
17	36	4.7	14.2	28	38	1.8	17.9	27
18	37	4.6	12.5	29	38	1.8	16.3	31
19	35	4.7	11.5	29	40	1.7	13.0	32
20	37	4.6	10.3	34	40	1.7	16.3	33

[a] Water from the Porcupine branch was turned off part of the day on Aug. 8, 12, and 15 and Sept. 11, and all day on Aug. 22.

Daily discharge, in second-feet, of Bonanza ditch for 1912—Continued.

Day.	Bonanza ditch below junction with Porcupine branch.				Bonanza ditch at outlet.			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
21	36	4.5	9.7	19.2	34	1.7	7.0	31
22	40	4.5	6.0	.....	34	1.5	3.5	.....
23	22	4.5	9.3	.....	31	1.5	6.4	.....
24	12.5	4.5	10.1	.....	22	1.4	7.8	.....
25	11.8	4.6	10.1	.....	21	1.4	7.8	.....
26	12.5	5.1	11.5	.....	22	1.6	9.6	.....
27	15.4	5.3	16.8	.....	20	2.6	13.3	.....
28	18.8	5.5	20	.....	23	2.9	18.8	.....
29	20	5.3	18.1	.....	25	3.1	12.0	.....
30	14.8	5.1	15.7	.....	17.9	3.8	10.5	.....
31	.....	5.1	10.6	.....	.....	4.2	.....	.....
Mean	24.6	5.61	12.5	21.4	28.9	3.87	10.4	21.4
Accuracy	B.	B.	B.	B.	A.	A.	A.	A.

FAIRBANKS DISTRICT.

GENERAL FEATURES.

The Fairbanks district extends about 60 miles to the north of Fairbanks and is from 40 to 50 miles wide. The greater part of it 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 basin.

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 of 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, which is wet, spongy, and mossy and ranges in thickness from 6 inches to 2 feet. In some localities this lowland area is meadow-like, producing a rank growth of grass and a variety of beautiful wild flowers. Ground ice is found beneath the turf 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, and 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.

The following list gives the locations at which gaging stations were maintained or discharge measurements made in 1912 in the Fairbanks district. Relation of streams is shown by indention.

Salcha River drainage basin:
- Junction Creek above Moose Lake outlet.

Chena River drainage basin:
- Chena River above Shamrock Creek.
- Chena River above Little Chena River.
- North Fork Chena River below Boulder Creek.
- North Fork Chena River above Monument Creek.
- North Fork Chena River below Monument Creek.
- Monument Creek at Chena Hot Springs.
- Frozenfoot Creek at elevation 1,500 feet.
- Frozenfoot Creek 2 miles above mouth.
- West Fork of Chena River, above Olympia Creek.
- Olympia Creek at mouth.
- Fish Creek below Solo Creek.

Chatanika River drainage basin:
- Smith Creek above Pool Creek.
- McManus Creek at mouth.
- Chatanika River below Faith Creek.
- Chatanika River below Poker Creek.
- Pool Creek at mouth.
- Hope Creek at mouth.
- Faith Creek at mouth.
- Charity Creek above Homestake Creek.
- Homestake Creek at mouth.
- Deep Creek at mouth.
- Poker Creek above ditch intake.
- Caribou Creek at mouth.

Beaver Creek drainage basin:
- Nome Creek, 4 miles above Moose Creek.
- Nome Creek above Ophir Creek.
- Ophir Creek at Discovery claim.

SALCHA RIVER DRAINAGE BASIN.

Salcha River rises opposite South Fork of Birch Creek, about 25 miles from the Yukon. The basin covers an area of 2,170 square miles and is bounded by the Goodpaster and Charley River basins on the south and east and the Chena and Birch Creek basins on the north. The length of the river from the headwaters to North Fork, following the general direction of the valley, is about 70 miles, and from the North Fork to the Tanana about 55 miles. The prevailing direction of flow is somewhat south of east. The Salcha roughly parallels the Chena at a distance of approximately 30 miles. The average fall of the river from the North Fork 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 road house are located. 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 and parallel to Tanana River.

Daily discharge, in second-feet, of Junction Creek above Moose Lake outlet for 1912.

[Drainage area, 23.6 square miles.]

Day.	June.	July.	Aug.	Sept.	Oct.	Day.	June.	July.	Aug.	Sept.	Oct.
1	70	28	4.3	5.4	.....	21	38	5.8	3.7	5.0	.....
2	94	26	4.3	6.2	.....	22	32	5.8	3.7	5.4	.....
3	70	22	4.3	6.2	.....	23	124	5.4	3.7	5.8	.....
4	52	18	4.0	5.8	.....	24	300	5.0	4.0	6.2	.....
5	36	16	4.0	5.4	.....	25	300	5.4	4.3	8.6	.....
6	32	32	3.7	5.0	.....	26	180	5.8	5.4	7.2	.....
7	20	10.2	4.3	4.6	.....	27	94	5.4	5.4	5.8	.....
8	12	8.6	4.0	5.4	.....	28	52	5.4	5.0	5.0	.....
9	7.2	7.2	4.3	5.0	.....	29	36	5.4	4.6	4.6	.....
10	5.4	6.7	4.6	4.6	.....	30	28	5.0	4.3	4.6	.....
11	5.0	5.8	5.4	4.6	.....	31	.....	4.6	4.6	.....	.....
12	38	5.8	4.6	4.6	.....	Mean	78.4	9.32	4.29	5.25	.....
13	40	5.8	4.6	4.3	.....	Mean per square mile	3.32	.395	.182	.222	.....
14	26	5.8	4.6	4.3	.....	Run-off (depth in inches on drainage area)	3.70	.46	.21	.25	.....
15	103	5.4	4.3	4.6	.....	Accuracy	D.	D.	D.	D.	.....
16	250	5.4	4.0	4.6	.....						
17	82	5.4	4.0	4.6	.....						
18	43	5.4	3.7	4.6	.....						
19	124	5.0	3.7	4.6	.....						
20	58	5.4	3.7	5.0	.....						

NOTE.—The above discharges are based on a rating curve that was fairly well defined by five measurements made during 1909 and 1910. The station was not visited by a member of the Survey during 1911 or 1912. The relation between the gage heights of previous years with those of 1912 as a measure of discharge is unknown, but it is believed that no very great changes have occurred.

CHENA RIVER DRAINAGE BASIN.

Chena River rises between the headwaters of Salcha River and South Fork of Birch Creek at an elevation between 4,000 and 5,000 feet. 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 the Chena Slough 10 miles above Fairbanks. It drains an area of 1,860 square miles.

The principal tributaries are Munson Creek and the South Fork from the south, and North Fork and Little Chena River from the north.

That part of Chena River above the North Fork is sometimes known as Middle Fork. It has a catchment of 540 square miles, the major part of which lies to the south. Munson Creek is the largest tributary and enters from the south about 45 miles from the head. Ottertail Creek is the largest stream from the north and enters about 8 miles above Munson Creek. Salmonfoot, Shamrock, Palmer, Teuchet, and Blackshell, in downstream order, are small branches from the south.

North Fork takes its source in the Yukon-Tanana divide at the head of Chatanika River and Harrington Fork of Birch Creek, and it joins the main stream about 10 miles below Munson Creek at an elevation of a little over 800 feet. West Fork is the largest tributary of North Fork, entering from the right about 12 miles above the mouth of the latter. Monument Creek, the only branch of consequence from the left limit, unites with North Fork about 3 miles above West Fork. West Fork rises in the divide between Harrington Fork of Birch

Creek and Pool Creek. Its two main tributaries are Frozenfoot and Olympia creeks.

South Fork is confluent to the Chena about 20 miles below North Fork. It drains an irregularly shaped area somewhat smaller than the North Fork basin.

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 is 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 3 or 4 miles above the confluence of Chena Slough.

The principal tributaries of Fish Creek are Bear, Fairbanks, and Miller creeks.

Daily discharge, in second-feet, of Chena River and North Fork of Chena River for 1912.

Day.	Chena River above Shamrock Creek.[a] [Drainage area, 157 square miles.]				Chena River above Little Chena. [Drainage area, 1,440 square miles.]			North Fork of Chena River above Monument Creek.[b] [Drainage area, 938 square miles.]		
	July.	Aug.	Sept.	Oct.	June.	July.	Aug.	June.	July.	Aug.
1	193	193	201	178	.....	2,500	1,200	.....	56	40
2	178	178	197	164	.....	2,130	1,090	.....	50	37
3	308	170	193	161	.....	1,930	1,040	.....	50	36
4	212	178	212	156	.....	1,860	1,020	.....	45	36
5	170	164	193	156	.....	1,780	944	.....	40	34
6	150	156	170	150	.....	1,680	896	.....	36	34
7	146	772	178	150	.....	1,430	866	.....	34	56
8	150	429	178	150	.....	1,290	855	.....	34	43
9	140	336	164	146	.....	1,170	1,150	.....	33	45
10	137	325	164	146	.....	1,090	1,290	.....	33	45
11	140	702	156	146	.....	1,040	1,160	.....	36	50
12	135	528	156	146	.....	1,000	1,110	.....	34	63
13	135	461	156	146	.....	974	1,160	.....	33	81
14	161	366	161	144	.....	944	.....	.....	36	63
15	164	336	164	144	.....	914	.....	.....	45	63
16	146	291	193	140	.....	968	.....	.....	40	56
17	156	280	212	140	5,270	1,030	.....	.....	43	.....
18	164	308	256	.....	5,500	968	.....	.....	40	.....
19	150	308	193	.....	4,030	920	.....	.....	43	.....
20	161	291	366	.....	5,780	992	.....	.....	43	.....
21	193	193	461	.....	6,180	980	.....	.....	48	.....
22	201	193	325	.....	4,530	980	.....	.....	43	.....
23	178	178	308	.....	4,080	1,080	.....	.....	40	.....
24	164	187	280	.....	6,900	1,080	.....	.....	30	.....
25	156	178	256	.....	9,050	1,060	.....	.....	36	.....

[a] These discharges are well defined between 150 and 300 second-feet.
[b] These discharges are well defined for all stages.

Daily discharge, in second-feet, of Chena River and North Fork of Chena River for 1912—Continued.

Day.	Chena River above Shamrock Creek. [Drainage area, 157 Square miles.]				Chena River above Little Chena. [Drainage area, 1,440 square miles.]			North Fork of Chena River above Monument Creek. [Drainage area, 938 square miles.]		
	July.	Aug.	Sept.	Oct.	June.	July.	Aug.	June.	July.	Aug.
26	161	232	243	.....	8,920	968	.....	.....	36	.....
27	325	256	230	.....	7,100	932	.....	.....	40	.....
28	397	232	217	.....	5,930	872	.....	119	66	.....
29	325	212	204	.....	3,440	1,030	.....	99	63	.....
30	308	193	191	.....	2,880	1,100	.....	70	50	.....
31	193	193	.....	.....	.....	1,310	.....	.....	43	.....
Mean	190	291	219	151	5,690	1,230	1,060	96.0	41.9	48.9
Mean per square mile	1.21	1.85	1.39	.961	.395	.854	.736	1.02	.447	.521
Run-off (depth in inches on drainage area)	1.40	2.13	1.55	.61	.21	.98	.36	.11	.52	.31
Accuracy	B.	C.	B.	A.	D.	C.	B.	A.	A.	A.

Daily discharge, in second-feet, of North Fork of Chena River, Monument Creek, and Fish Creek for 1912.

Day.	North Fork of Chena River below Monument Creek.[a] [Drainage area, 129 square miles.]			Monument Creek at Chena Hot Springs. [Drainage area, 30.1 square miles.]			Fish Creek below Solo Creek.[b] [Drainage area, 21.5 square miles.]		
	June.	July.	Aug.	June.	July.	Aug.	June.	July.	Aug.
1	.....	98	78	.....	29	25	.....	.....	.....
2	.....	90	67	.....	28	24	.....	.....	.....
3	.....	87	64	.....	26	24	.....	.....	.....
4	.....	80	64	.....	24	24	.....	.....	.....
5	.....	73	67	.....	23	24	.....	.....	11.0
6	.....	67	59	.....	22	24	.....	15.1	10.1
7	.....	64	124	.....	20	63	.....	.....	.....
8	.....	50	92	.....	21	44	.....	.....	.....
9	.....	59	103	.....	20	53	.....	10.5	.....
10	.....	56	83	.....	20	33	.....	.....	.....
11	.....	50	106	.....	21	44	.....	.....	.....
12	.....	59	90	.....	20	53	27	33	.....
13	.....	56	106	.....	20	37	.....	.....	.....
14	.....	64	98	.....	25	57	19.3	22	.....
15	.....	78	90	.....	28	33	.....	.....	.....
16	.....	70	84	.....	24	37	.....	.....	9.4
17	.....	78	.....	.....	29	.....	.....	24	.....
18	.....	87	.....	.....	31	.....	64	.....	.....
19	.....	84	.....	.....	29	.....	.....	.....	.....
20	.....	78	.....	.....	25	.....	.....	.....	.....
21	.....	84	.....	.....	26	.....	.....	15.1	.....
22	.....	78	.....	.....	26	.....	46	.....	.....
23	.....	70	.....	.....	24	.....	.....	.....	.....
24	.....	64	.....	.....	26	.....	72	19.3	.....
25	.....	61	.....	.....	21	.....	.....	.....	.....
26	.....	64	.....	.....	23	.....	56	.....	.....
27	.....	98	.....	.....	63	.....	.....	.....	.....
28	161	133	.....	48	74	.....	.....	15.1	.....
29	142	106	.....	39	44	.....	19.3	.....	.....
30	114	87	.....	33	29	.....	.....	12.0	.....
31	.....	80	.....	.....	26	.....	.....	.....	.....
Mean	139	75.9	85.9	40.0	28.0	37.4	.....	.....	.....
Mean per square mile	1.08	.588	.666	1.33	.930	1.24	.....	.....	.....
Run-off (depth in inches on drainage area)	.12	.68	.40	.15	1.07	.74	.....	.....	.....
Accuracy	D.	D.	D.	A.	A.	A.	.....	.....	.....

[a] These discharges are only approximate because of inaccuracies in gage readings and poor measuring conditions.

[b] Discharge curve fairly well defined below 40 second-feet.

Miscellaneous measurements in Chena River drainage basin, 1912.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-feet.*	*Sec.-feet.*
July 19	North Fork of Chena River below Boulder Creek	49.6	24	0.48
July 22	Frozenfoot Creek at elevation 1,500 feet	21.0	7.9	.38
Do	Frozenfoot Creek 2 miles above mouth	40.8	14.0	.34
Do	West Fork of Chena River above Olympia Creek	106	32	.30
Do	Olympia Creek at mouth	23.6	22	.93

CHATANIKA RIVER DRAINAGE BASIN.

Chatanika River is formed by the junction of Faith and McManus creeks, which drain the high 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 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 north of Tanana River. About 10 miles from its mouth Goldstream Creek, its largest tributary, joins it from the south.

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 north are short and precipitous, flowing through V-shaped valleys; those from the south have less

precipitous courses and broader valleys and gradually lose themselves in the rather broad expanse of swamplike bottom lands.

Smith Creek is the principal tributary of McManus Creek, entering it from the south about a mile above Faith Creek. Pool Creek joins Smith Creek from the east about a mile above McManus Creek. Hope, Charity, Homestake, and Deep creeks are headwater branches of Faith Creek.

Monthly discharge of Chatanika River below Faith Creek for 1907–1912.

[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
September 1–25	430	141	233	1.77	1.65
The period, 124 days	2,000	48	235	1.78	8.24
1911.					
May 24–31	1,010	408	691	5.23	1.56
June	836	140	441	3.33	3.72
July	334	28	101	.765	.88
August	1,280	24	146	1.11	1.27
September 1–24	125	53	79.8	.604	.54
The period, 124 days	1,280	24	228	1.73	7.97
1912.					
May 15–31	880	206	457	3.46	2.18
June	1,500	121	427	3.23	3.60
July	244	55	86.4	.655	.76
August	188	75	109	.826	.95
September	350	101	170	1.29	1.44
The period, 139 days	1,500	55	228	1.73	8.93

Monthly discharge of Chatanika River below Poker Creek for 1907–1912.

[Drainage area, 456 square miles.]

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
October 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
October 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
October 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
October 1–29	352	123	208	.456	.49
The period, 166 days	3,260	95	472	1.04	6.38
1911.					
May 6–31	3,500	1,170	2,550	5.59	5.41
June	1,760	283	818	1.79	2.00
July	566	109	276	.605	.70
August	1,740	88	372	.816	.94
September	422	147	262	.575	.64
October	330	87	167	.366	.42
November 1–5	101	87	94.8	.208	.04
The period, 184 days	3,500	87	677	1.48	10.15
1912.					
June 13–30	3,470	441	1,490	3.27	2.19
July	441	175	256	.561	.65
August	394	175	243	.533	.61
September	872	210	340	.746	.83
October 1–26	259	132	191	.419	.41
The period, 136 days	3,470	132	425	.932	4.69

Discharge, in second-feet, of McManus Creek and Chatanika River for 1912.

Day.	McManus Creek at mouth.[a] [Drainage area, 80 square miles.]					Chatanika River below Faith Creek.[b] [Drainage area, 132 square miles.]				
	May.	June.	July.	Aug.	Sept.	May.	June.	July.	Aug.	Sept.
1	.....	257	53	39	48	.....	660	106	97	101
2	.....	508	48	30	60	.....	1,500	92	82	126
3	.....	426	53	30	72	.....	1,130	97	82	140
4	.....	232	44	30	72	.....	562	86	82	140
5	.....	141	39	27	86	.....	301	71	79	156
6	.....	100	30	24	78	.....	232	68	75	149
7	.....	71	30	72	60	.....	181	62	155	126
8	.....	58	30	60	60	.....	140	62	140	126
9	.....	84	30	48	60	.....	172	58	121	126
10	.....	79	24	44	48	.....	162	55	106	114
11	.....	58	24	67	48	.....	126	55	149	114
12	.....	122	27	78	48	.....	244	58	188	101
13	.....	204	24	60	48	.....	413	58	149	101
14	.....	122	30	48	48	.....	288	86	126	101
15	288	84	30	48	72	730	224	75	121	132
16	310	141	27	39	86	880	310	65	101	155
17	257	115	30	39	126	730	265	65	101	217
18	215	90	30	39	160	595	206	68	97	257
19	166	402	30	39	126	500	1,080	62	92	217
20	115	204	30	34	186	371	470	71	86	350
21	115	122	30	34	186	371	288	75	86	335
22	100	109	30	34	150	310	244	68	86	265
23	177	522	27	34	126	360	1,040	68	86	232
24	79	346	24	39	100	301	695	62	92	206
25	71	355	24	44	86	206	660	58	97	188
26	63	239	30	53	86	206	442	86	114	181
27	58	160	44	67	72	206	288	162	132	155
28	166	116	67	60	72	371	206	244	126	155
29	301	86	53	48	78	695	149	188	114	162
30	192	67	48	48	86	413	121	132	106	172
31	122	.....	39	48	.....	530	.....	114	101	.....
Mean	164	187	34.8	45.3	87.8	457	427	86.4	109	170
Mean per square mile	2.05	2.34	.435	.507	1.10	3.46	3.23	.655	.826	1.29
Run-off (depth in inches on drainage area)	1.30	2.61	.50	.58	1.23	2.18	3.60	.76	.95	1.44
Accuracy	B.	C.	A.	A.	A.	B.	B.	A.	A.	A.

[a] These discharges are fairly accurate below 400 second-feet.
[b] These discharges are well defined below 600 second-feet.

Daily discharge, in second-feet, of Chatanika River and Faith Creek for 1912.

Day.	Chatanika River below Poker Creek.[a] [Drainage area, 456 square miles.]					Faith Creek, at mouth.[b] [Drainage area, 51 square miles.]				
	June.	July.	Aug.	Sept.	Oct.	May.	June.	July.	Aug.	Sept.
1	.....	330	228	188	259	.....	334	59	59	50
2	.....	293	214	200	244	.....	780	56	54	56
3	.....	276	228	214	228	.....	589	59	50	56
4	.....	259	214	259	214	.....	254	54	50	56
5	.....	214	200	259	228	.....	142	44	46	63
6	.....	188	200	259	228	.....	118	44	44	59
7	.....	176	312	259	228	.....	91	39	78	56
8	.....	153	372	228	228	.....	87	39	73	56
9	.....	153	259	228	214	.....	84	36	59	56
10	.....	153	228	214	200	.....	73	34	56	50
11	.....	153	259	214	200	.....	56	34	70	50
12	.....	176	330	200	200	.....	107	34	91	44
13	1,140	176	312	200	200	.....	210	34	73	44
14	815	200	259	188	176	.....	177	59	63	44
15	585	244	259	200	176	254	129	50	59	50
16	815	228	228	228	176	334	190	42	56	56
17	1,220	200	214	293	176	293	134	42	50	73
18	715	214	200	498	176	334	118	42	44	84
19	3,450	228	176	470	176	247	538	36	44	111
20	2,580	228	176	470	164	210	236	42	44	111
21	1,220	259	164	850	164	200	142	44	44	107
22	885	228	164	650	164	168	129	44	44	87
23	2,580	214	153	498	153	377	421	44	44	73
24	3,350	214	153	470	132	154	254	39	44	70
25	2,130	214	153	372	132	134	247	36	46	70
26	1,780	214	176	312	132	129	160	56	54	67
27	1,300	259	200	293	.....	118	125	118	59	63
28	850	351	214	293	.....	210	97	177	56	63
29	585	419	214	276	.....	334	73	134	56	67
30	419	372	200	259	.....	168	67	78	54	70
31	.....	276	200	.....	.....	293	.....	70	50	.....
Mean	1,470	234	221	318	191	233	205	55.5	55.3	65.4
Mean per square mile	3.22	.513	.485	.697	.419	4.57	4.02	1.09	1.08	1.28
Run-off (depth in inches on drainage area)	2.16	.59	.56	.78	.41	2.89	4.48	1.26	1.24	1.43
Accuracy	B.	A.	A.	A.	A.	.....	.....	.....	.....	.....

[a] A ditch diverted water from the river above the gage from about May 15 to Sept. 30. The mean of five discharge measurements made during the summer was 26 second-feet, which was probably about the average diversion for the season and should be added to the above discharges to obtain the natural flow of the river. The discharges are well defined below 1,200 second-feet. Ice formed 3 feet from shore at the gage on Oct. 18. The river froze over on Oct. 27.

[b] Discharges are well defined below 400 second-feet.

Daily discharge, in second-feet, of Charity Creek and Homestake Creek for 1912.

Day.	Charity Creek above Homestake Creek.				Homestake Creek at mouth. [Drainage area, 5.8 square miles.]			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1	.....	7.0	4.6	4.6	.....	4.4	2.5	3.4
2	.....	6.7	4.4	5.0	.....	3.6	2.3	3.8
3	.....	6.5	4.4	5.4	.....	3.1	2.2	4.4
4	.....	6.2	3.9	5.6	.....	2.7	2.1	4.9
5	.....	5.8	3.7	5.8	.....	2.5	2.0	5.2
6	.....	5.4	3.7	6.0	.....	2.3	2.0	4.9
7	.....	5.0	4.2	5.4	.....	2.2	2.3	4.0
8	.....	4.6	4.2	5.4	.....	2.0	2.3	3.8
9	8.9	4.6	3.9	5.0	6.9	1.7	2.2	3.6
10	8.1	4.4	3.9	4.8	5.9	1.7	2.2	3.4
11	7.0	5.2	6.7	.....	4.9	2.0	4.9	.....
12	8.9	4.8	5.2	.....	11.1	1.7	4.0	.....
13	10.8	4.6	4.8	.....	10.2	1.6	3.6	.....
14	8.9	4.4	4.6	.....	8.2	1.6	3.3	.....
15	11.1	4.2	4.4	.....	9.5	1.6	3.3	.....
16	17.6	4.4	4.4	.....	10.2	1.7	3.6	.....
17	13.1	4.8	4.2	.....	8.2	1.8	3.8	.....
18	8.9	5.0	4.0	.....	6.9	2.0	3.4	.....
19	32	4.8	3.9	.....	44	1.8	3.1	.....
20	16.6	5.2	3.9	.....	14.8	2.2	2.9	.....
21	12.6	5.0	4.0	.....	10.2	2.1	3.3	.....
22	11.9	4.2	3.9	.....	10.2	1.6	2.9	.....
23	60	4.4	4.2	.....	58	1.7	3.3	.....
24	24	3.7	4.2	.....	27	1.3	3.3	.....
25	17.6	3.7	4.0	.....	15.5	1.3	2.9	.....
26	15.6	5.0	4.4	.....	11.1	2.3	3.4	.....
27	11.5	5.6	4.2	.....	8.2	2.9	3.3	.....
28	8.9	5.8	4.4	.....	6.9	4.4	3.6	.....
29	8.4	5.2	4.2	.....	5.4	3.6	3.3	.....
30	7.8	4.8	4.2	.....	4.9	2.9	2.9	.....
31	.....	4.6	4.0	.....	.....	2.5	2.5	.....
Mean	15.0	5.02	4.28	5.30	13.6	2.28	2.99	4.14
Mean per square mile	.....	.....	.....	.....	2.43	.407	5.34	.739
Run-off (depth in inches on drainage area)	.....	.....	.....	.....	1.99	.47	.62	.27
Accuracy	C.	A.	A.	A.	B.	A.	A.	A.

NOTE.—Discharge rating curve for both stations well defined below 10 second-feet.

Miscellaneous measurements in Chatanika River drainage basin, 1912.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
July 23	Smith Creek above Pool Creek	17.0	3.6	0.21
Do	Pool Creek at mouth	14.0	5.9	.42
June 10	Hope Creek at mouth	20.3	24	1.18
July 24	do	20.3	20	.99
August 16	do	20.3	23	1.13
Do	Deep Creek at mouth		7.6	
June 21	Poker Creek above ditch intake	18.1	45	2.49
Do	Caribou Creek at mouth	17.7	28	1.58
June 13	Chatanika ditch near outlet		21	
June 14	do		24	
June 20	do		14.5	
July 29	do		36	
August 11	do		33	

BEAVER CREEK DRAINAGE BASIN.

Beaver Creek drains an area of 5,360 square miles lying north of Chatanika River between Preacher Creek on the east and Tolovana River and Hess Creek on the west. It joins the Yukon from the south about 40 miles below Birch Creek and nearly opposite Hosiana River. It is formed by the junction of Big Champion and Little Champion creeks, whose headwaters interlock with those of Preacher Creek. It flows westward for about 25 miles and then makes a right-angle turn around the southern extremity of the White Mountains and gradually assumes a northeasterly course, which it follows until it leaves the foothills and enters the flats of the Yukon, where it makes an abrupt turn to the northwest and meanders in a tortuous course to its mouth.

The average fall between Nome Creek and Fossil Creek is about 12 feet to the mile. The principal tributaries, named in order downstream, are Roy, Bryan, Brigham, Fossil, Willow, and Mascot creeks on the right and Nome, Trail, Wickersham, and Victoria creeks on the left.

Ophir Creek is the largest branch of Nome Creek and enters it from the south about a mile above Beaver Creek.

Daily discharge, in second-feet, of Nome Creek for 1912.

Day.	Nome Creek, 4 miles above Moose Creek.				Nome Creek above Ophir Creek. [Drainage area, 76 square miles.]			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1	.....	24	30	18.0	.....	94	57	56
2	.....	18.0	27	18.0	.....	83	51	56
3	.....	18.0	25	24	.....	76	46	66
4	.....	18.0	24	24	.....	67	48	76
5	.....	18.0	24	24	.....	61	45	88
6	.....	14.0	24	24	.....	53	44	90
7	.....	14.0	24	24	.....	47	52	72
8	.....	14.0	24	21	.....	45	73	60
9	.....	14.0	24	21	.....	41	64	56
10	.....	14.0	24	21	.....	40	56	52
11	.....	14.0	42	18.0	.....	40	61	48
12	.....	21	33	18.0	.....	42	98	46
13	.....	14.0	24	18.0	.....	44	76	44
14	.....	53	24	18.0	.....	73	60	42
15	.....	59	21	24	.....	67	53	53
16	.....	42	21	30	.....	51	47	66
17	.....	32	18.0	40	.....	48	51	106
18	.....	32	18.0	50	.....	61	44	162
19	.....	21	18.0	24	.....	51	41	133
20	.....	21	16.0	24	.....	64	41	183
21	.....	30	16.0	.....	306	87	38	178
22	.....	35	18.0	.....	291	83	37	133
23	.....	35	18.0	.....	764	73	37	92
24	.....	25	18.0	.....	696	57	40	73
25	138	19.8	18.0	.....	566	51	48	.....
26	107	48	24	.....	440	73	64	.....
27	65	122	32	.....	320	157	87	.....
28	51	138	37	.....	222	183	76	.....
29	37	100	28	.....	152	143	61	.....
30	24	50	24	.....	124	94	57	.....
31	.....	40	21	.....	.....	90	56	.....
Mean	70.4	36.1	23.8	24.2	388	71.6	55.1	84.2
Mean per square mile	.....	.....	.....	.....	5.11	.942	.724	1.11
Run-off (depth in inches on drainage area)	.....	.....	.....	.....	1.90	1.09	.83	.99
Accuracy	A.	A.	A.	A.	B.	A.	A.	A.

NOTE.—The above discharges are well defined for all stages.

Miscellaneous measurements in Beaver Creek drainage basin, 1912.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
June 22	Ophir Creek at Discovery claim	22.1	28	1.27
Do	do	22.1	62	2.81
June 23	do	22.1	165	7.47
July 27	do	22.1	22	1.00
August 13	do	22.1	6.7	.30

GOLD PLACERS OF THE RUBY DISTRICT.

By HENRY M. EAKIN.

LOCATION AND EXTENT OF THE DISTRICT.

The chief settlement of the Ruby district is Ruby, situated on the south bank of Yukon River opposite the mouth of Melozitna River. The principal placer mines of the district are about 25 miles south of Ruby on a number of streams that belong to the Nowitna River system. The area that includes the mines is small, but auriferous gravels have been found in the surrounding territory extending from the Yukon southward 50 miles or more, with a width somewhat less in extent. (See general map, Pl. X.)

PREVIOUS INVESTIGATIONS.

The earliest geologic work that touched definitely upon this general region was that of Spurr, who made an exploration of the Kuskokwim Valley in 1898.[1] Collier took some notes on the rocks which outcrop in the bluff near Ruby Creek in 1902, but they were not published, being foreign to the special study of the coal-bearing terranes in which he was engaged. In 1908 Maddren spent a short time in an investigation of the region about the southern headwaters of Innoko River and in 1910 visited the Ruby, Innoko, and Iditarod districts.[2] During that year a topographic reconnaissance was carried by C. G. Anderson from Yukon River at the present site of the town of Ruby to the Innoko and Iditarod districts. Mr. H. E. Birkner, of the Anderson party, made some geologic observations along the route of travel.

FIELD WORK.

During the summer of 1912 the writer visited the Ruby, Innoko, and Iditarod districts. Work was begun at Ruby July 18. The two following weeks were spent in a geologic reconnaissance of the district and in visiting the producing creeks. The reconnaissance was then extended southwest to the Innoko district and thence to the

[1] Spurr, J. E., Reconnaissance in southwestern Alaska in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, 1900, pp. 31–264.

[2] Maddren, A. G., The Innoko gold-placer district, Alaska: U. S. Geol. Survey Bull. 410, 1910; Gold placer mining developments in the Innoko-Iditarod region: U. S. Geol. Survey Bull. 480, pp. 236–270, 1911; The Ruby placer district: U. S. Geol. Survey Bull. 520, pp. 287–296, 1912.

Iditarod district, where work was suspended September 10. The placer mines of the Innoko-Iditarod region are treated elsewhere in this report. (See pp. 293–303.) A more comprehensive report on the Iditarod-Ruby region is in preparation, which will be accompanied by topographic and geologic maps.

GEOGRAPHY.

SIZE OF THE GOLD-BEARING AREA.

The mining center of the Ruby district is about 25 miles south of Yukon River at Ruby and comprises half a dozen creeks, all within an area a few miles square. The reports of prospectors indicate that a fairly continuous gold-bearing area extends from the Yukon at Ruby southward 50 miles or more with a width somewhat less in extent. The district has no strict boundaries and the present discussion pertains not only to the gold-bearing area but also to adjacent territory whose study sheds light upon the broader geologic relations (Pl. X).

RELIEF.

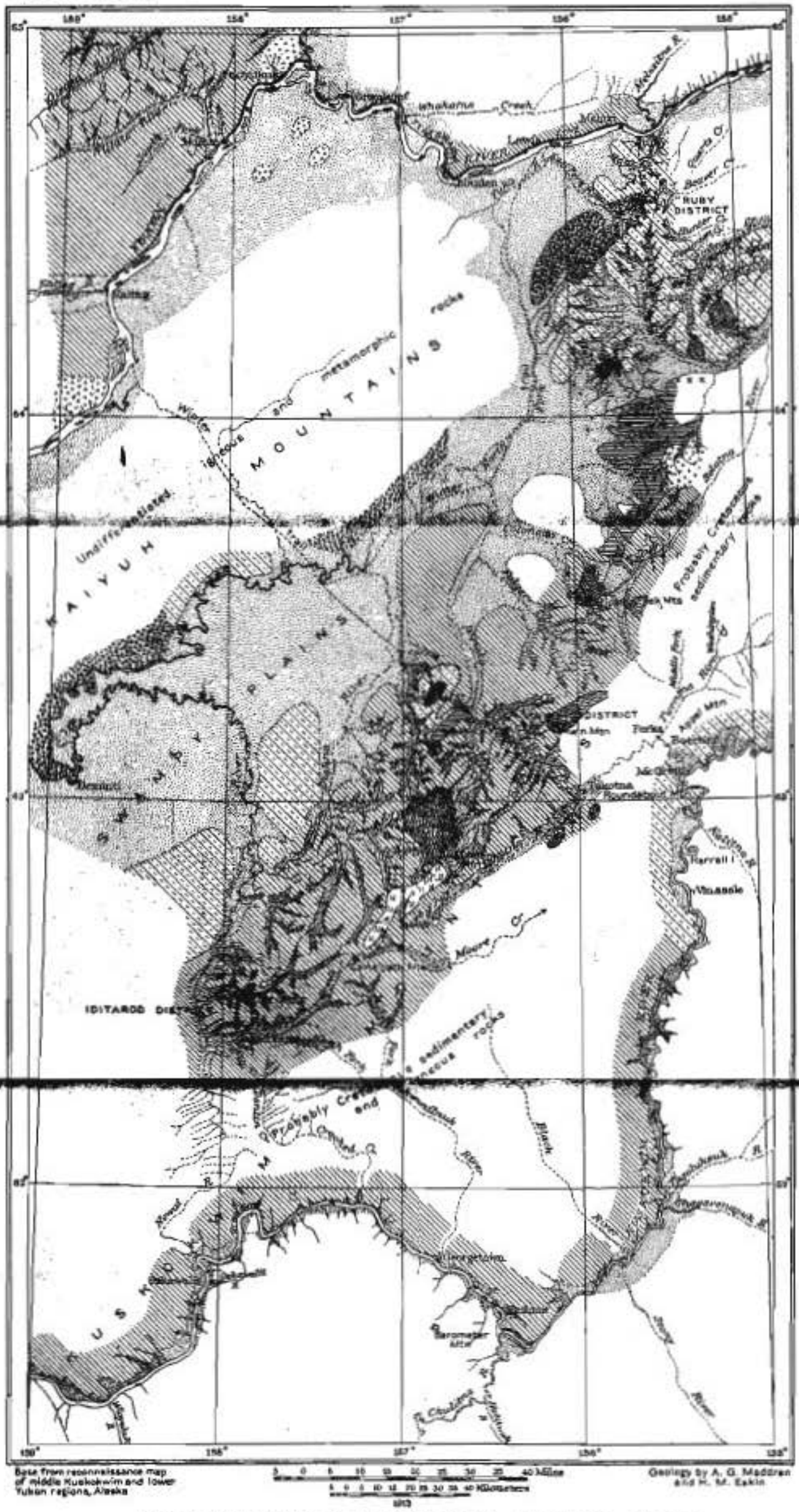
The Ruby district has for the most part a gently rolling topography characterized by broad ridges and dome-like hills of moderate relief. The headwater tributaries of the larger streams are singularly few and widely spaced, the smallest streams being of considerable length and free of laterals and gullies. Stream grades are low and their headward steepening very slight. The slopes of the hills and ridges diminish toward the summits, which are nowhere actually flat, and toward the stream bottoms, where flood plains of considerable width are the rule, even in the smallest streams. Most of the flood plains widen downstream and those of the larger streams are commonly several miles across.

The rolling type of topography is broken in two localities. In the western part of the district is a prominent group of hills of more rugged outline, which is the northeastern extension of the Kaiyuh Mountains. Their maximum elevation is about 2,200 feet. In the vicinity of Ruby the rolling hills break up along Yukon River in steep and in many places precipitous bluffs, 300 to 400 feet high.

The erosional cycle affecting the region has long since passed maturity and is approaching old age. This result has probably been hastened by changes in the major drainage features in late geologic time that have caused an adjustment of the smaller streams to a higher base level of erosion.

DRAINAGE.

Details concerning the courses and relationships of the numerous streams of the district can best be learned from the accompanying map (Pl. X). Some of the streams are directly tributary to the



GEOLOGIC SKETCH MAP OF THE RUBY, INNOKO, AND IDITAROD DISTRICTS.

Yukon, some flow southward and eastward to join Nowitna River, others flow westward into the Yukon basin, whereas the North Fork of the Innoko receives the waters from the southwestern part of the district.

The streams flowing directly into the Yukon named from west to east are Main, Oro, Flat, Center, Melozitna, Ruby, Short, Hanna, Big, and Independence creeks. South of Independence Creek are Quartz and Beaver creeks, which debouch upon the Nowitna lowlands and are probably tributary to the Nowitna. The rest of the Nowitna drainage is delivered through its large western tributary, Solatna River. The principal tributaries of the Solatna from the north, beginning with the lowest, are Flint, Tip, Trail, Quartz, Monument, and Long creeks. The southern tributaries of the Solatna no doubt have been named but no map of them is available. Likewise the streams tributary to the North Fork of the Innoko and Yuko River have not been adequately mapped, although many have been named by persons locating placer claims on them.

CLIMATE.

The Ruby district has, in common with the greater part of the lowlands of central Alaska, a sub-Arctic climate marked by great seasonal variation in temperature, rather scanty rainfall, and infrequency of storms. Winter weather may be experienced from October to April. The other months are for the most part usually mild. The larger streams as a rule thaw in early May and freeze over in late October. Most of the intervening period—usually about 120 days—is available for mining operations. The growing season for the hardier forms of vegetation is from early May to early September. Ninety to one hundred days of midsummer are usually free from frost.

The annual rainfall may be as little as 10 inches and rarely if ever exceeds 20 inches. It comes mostly as rain during the months of July and August. Thunderstorms occur during a short space of midsummer and may be accompanied by considerable precipitation. The sky is generally overcast during the time of the later rains, which, although not violent, may continue for several days or even weeks and make up the greater part of the year's precipitation. The summer of 1912 probably had an exceptionally heavy rainfall. The writer experienced only five days between July 17 and September 2 without rain.

Contrary to the popular conception of the climate of all high latitudes, violent storms are of comparatively rare occurrence in central Alaska both summer and winter. The length of periods without gales or even strong winds is commonly much greater than in the temperate latitudes.

The mean annual temperature is so low that the ground below a slight depth is in most localities permanently frozen. Extremely permeable gravel deposits are usually thawed, owing to the circulation of ground waters.

The thick vegetal mantle covering the region acts as a reservoir for the rain water and consequently the streams have a remarkably even flow. Owing to the frozen subsoil, practically the entire rainfall escapes as surface water, so that streams draining very small areas are often available for mining uses.

FORESTS AND VEGETATION.

The Ruby district is forested for the most part by a scant growth of spruce with scattered tamarack and birch. Small portions of the higher areas are free from timber of any sort. Trees 1 to 2 feet in diameter, suitable for lumber, are to be found along the banks of the larger streams and on the steep slopes at the heads of valleys.

Throughout the district the mosses common to Alaska are especially abundant and grasses adapted for forage are correspondingly scarce. The traveler finds a soft footing, laborious to traverse, and can find camping grounds that have available forage only with difficulty.

FISH AND GAME.

Salmon and several other varieties of fishes are available on Yukon River. In the smaller streams that are unpolluted by mining operations grayling are plentiful. The game is limited almost entirely to ptarmigan, grouse, and rabbits, which are plentiful. Two moose were killed on Long Creek in the spring of 1912, but their presence in the district was considered exceptional. Bear are found but are not numerous.

WATER SUPPLY.

All the drift mining of the district is on streams sufficiently large to furnish the water needed. On the smaller streams, where open-cut methods of mining are necessary, the water supply is scant for groundsluicing and even for the sluice boxes during the drier part of the season. At such times work is often seriously retarded.

SETTLEMENT AND POPULATION.

The principal settlement of the Ruby district is the town of Ruby, situated on the south bank of the Yukon, opposite the mouth of Melozitna River. Its average population during 1912 was probably about 1,000. The district had an additional population of about 300, mostly engaged in prospecting and mining on a group of streams 25 to 30 miles south of Ruby. Part of this number were localized in a small settlement known as "Long," near Discovery claim on Long Creek.

HISTORY AND DEVELOPMENT.

The first discovery of gold in the Ruby district was probably that made in 1907 on Ruby Creek, near the site of the present town. The value of the production from this locality is uncertain, estimates ranging from a few hundred to two thousand dollars. The original discovery proved to be of no great importance, and it was not until 1910 that the discoveries on Long Creek and its tributaries were made that created a widespread interest in the region and led to the development of the present mining district and the settlement of the town of Ruby. The discovery was made by Fernander and Johnson, near the mouth of Bear Pup, a tributary of Long Creek, late in July, 1910. A large number of people arrived during the following summer, and valuable deposits were located on several other creeks in the neighborhood. A substantial town was built in a single summer on the banks of the Yukon at the mouth of Ruby Creek and was given the name of Ruby. Since then the population of the district has remained over a thousand. The business of the town has assumed good proportions. Stores, hotels, etc., have been built, sawmills installed, a telephone line put in service between the town and the creeks, and a telegraphic connection has been made with the Government line on the opposite side of the river. About 25 plants of different kinds were operating on six creeks during all or a part of the summer of 1912. Though most of these outfits were using hand methods, several steam plants were in operation, and additional machinery was being received at Ruby to be installed during the winter of 1912.

TRANSPORTATION AND OTHER COSTS AFFECTING DEVELOPMENT.

The situation of Ruby on the Yukon affords excellent transportation facilities during the summer months, when numerous steamboats ply the river. The fare from Seattle to Ruby, first class, via Skagway, in 1912 was $124. Freight for Ruby is usually sent via St. Michaels. The rate on general merchandise from Seattle in 1912 was $40 a ton. Special classes of goods, such as extra heavy machinery, explosives, and articles of exceptional bulk, were charged 20 to 200 per cent above this rate.

Travel from Ruby to the mining center at Long is difficult in summer, owing to the unimproved condition of the trails. In winter, however, the trails are excellent. Summer and winter freight rates show a corresponding difference. The summer charge to Long Creek in 1912 was 12½ cents a pound, to Trail Creek 15 cents a pound. The winter rates were 5 and 6 cents a pound to Long and Trail creeks, respectively.

Labor in the district was plentiful in 1912. Wages for ordinary workmen were $5 a day and board, for carpenters and mechanics $7.50 to $12 a day and board.

Rough lumber in 1912 sold in Ruby at $50 a thousand feet, dressed lumber at $80 a thousand feet. Cordwood brought $6 at Ruby and sold as high as $10 or $12 on some of the creeks.

The road houses commonly charge $1.50 for a meal and $1 for lodgings.

GENERAL GEOLOGY.

NATURE OF THE ROCKS.

A group of metamorphic rocks, principally of sedimentary origin but including some igneous members, comprises the bedrock of most of the Ruby district. There are minor areas of unaltered igneous rocks, and numerous unaltered dikes and sills cut the metamorphic rocks. Unaltered sedimentary rocks, probably of Cretaceous age, occur in the hills north of the Yukon opposite Ruby. The unconsolidated deposits of the district include present stream gravels, bench gravels, silts, and residual clays. (See geologic map, Pl. X.)

METAMORPHIC ROCKS.

The metamorphic rocks are principally schists, slates, limestones, cherts, and greenstones. The exposures along the Yukon bluffs near Ruby are mainly black quartzitic slate and limestone. The absence of slaty cleavage in places gives black quartzite and quartzite schist phases of the same original rock as that forming the slates. The schists and slates are much contorted and contain numerous quartz veins and lenses and unaltered dikes of varying composition. The limestones are crystalline, banded bluish and white in color, and have complicated structures that indicate a dynamic history similar to that of the schists and slates.

The prominent hills about the head of Long Creek are mostly formed of a quartzose schist. This schist is light colored and in places contains much mica. A little to the northwest of this locality, on the divide between Beaver and Main creeks, dark-colored limestone is associated with more or less sheared cherts.

Exposures of bedrock are not numerous on Long Creek or Bear Pup near the mines, but types of rock like those already described are found. A considerable part of the bedrock here is greenstone, but limestone and schists predominate. The greenstones have more or less schistose cleavage developed and grade into greenstone schists.

On Glen Gulch the bedrock is mostly a crenulated graphitic schist, cut by numerous quartz veins. The stream gravels contain green-

stone and mica schist pebbles, derived from masses which probably form the bedrock in parts of the valley.

The bedrock of Trail Creek basin is like that of Glen Gulch with respect to the metamorphic rocks, consisting of limestones, greenstones, and black crenulated schists. The same abundance of quartz veins is also present.

The metamorphic rocks described above extend from the Yukon southward to a point about 10 miles south of Twin Butte Mountain, where the smooth rolling topography gives place to a series of sharp hills and ridges composed of chert and igneous rocks. Westward the metamorphic rocks extend to the border of the Kaiyuh Mountains, which are mainly of less altered igneous rocks. Eastward they extend beyond the boundaries of the district.

The structure of the metamorphic rocks is rarely evident but is uniformly complex wherever recognized. The principal structural axes trend in general N. 25° E. Along these axes intense folding and faulting have taken place. There has also been much shearing on a small scale and the secondary structure thus developed conforms in general with the major axes. The metamorphism of the original sedimentary and igneous rocks now represented in the group is largely due to the processes attending their deformation. A similar effect has also been induced by igneous activities accompanying their intrusion by large granitic masses and various dikes.

The structural trend of the metamorphic rocks of the Ruby district is northeastward toward the Gold Mountain and Rampart districts, where similar rocks are found. They are probably the equivalents of some of the formations that occur in these districts and farther eastward in the Fairbanks and Circle quadrangles. If so, they are probably of early Paleozoic age, possibly Silurian or Devonian.

UNALTERED SEDIMENTARY ROCKS.

The hills bordering the Melozitna delta north of Yukon River opposite Ruby are formed of shale, sandstone, and conglomerate. The extent of these beds northward was not determined, but they form a belt at least several miles in width which trends northeast and southwest along the Yukon. No other rocks of this character were seen in the district. The shales are dark colored and in some places are very graphitic. They are in general thinly bedded, alternating with thin beds of fine sandstone. Slaty cleavage has been developed in places in both the shales and standstones. The heavier sandstone beds are massive and owing to their hardness form the highest hills and ridges. Their coarser phases grade into grits and fine conglomerates. They are generally gray in color, weathering brown, and evidently contain much material besides quartz.

These beds carry fossil leaves, although no determinable specimens were secured. Owing to this fact and their apparent continuity with the Cretaceous beds that outcrop along the Yukon farther west, which they resemble, these beds are regarded as Cretaceous in age.

IGNEOUS ROCKS.

The igneous rocks of the Ruby district include old, more or less altered basic rocks associated with the metasedimentary rocks throughout the district, a series of basic flows that form an extension of the Kaiyuh Mountains, rhyolite porphyry and quartz diorite intrusives younger than the basic flows, and still younger granitic intrusions.

The old basic rocks are represented on Long Creek and on the divide between Bear Pup and Glen Gulch by actinolite-epidote schists. On Midnight Creek the old basic rocks are diorites and at Twin Butte Mountain diabase. These rocks are all types of the so-called greenstones and are common in all the metamorphic areas.

The rocks of the northeastern extension of the Kaiyuh Mountains within the district are ultrabasic flows. They are principally diabase and quartz gabbro, but some more acidic types approaching rhyolites in composition are found. Their textures vary from medium granular to aphanitic, and some of the finer-textured rocks contain considerable glass. In addition to the area near the mountains this group of rocks extends northeastward and forms the landmark known as the "Thumb," near the head of Beaver Creek. These rocks show more or less alteration and are probably not greatly different in age from those associated with the metamorphic rocks.

Several dikes cut the metamorphic rocks in the Yukon bluffs near Ruby. They range in composition from rhyolite porphyry to quartz diorite. Similar dikes cut the metamorphic and older igneous rocks in other parts of the district. In all places noted they conform with the structure of the older rocks and were intruded subsequent to their principal deformations.

Unaltered granites occupy considerable areas near the heads of Trail and Flint creeks. These rocks are coarsely granular and disintegrate so readily that as a rule they have no special topographic expression. At the head of Flint Creek, however, they form a number of pinnacles 10 to 50 feet high, called the Monument Rocks. Some phases of the granite are remarkable for the abundance of sulphides present in them. The granites are apparently in the form of batholiths, a mile or more in diameter. They are unsheared and must have been injected into the metamorphic rocks since the principal period of deformation.

VEINS AND MINERALIZATION.

Quartz veins are a common feature of the metamorphic rocks throughout the Ruby district. They are especially abundant in the black crenulated schist that outcrops on the head of Boston Creek and on Trail Creek. Brecciated quartz veins are commonly exposed in the bedrock of the placer mines on all the creeks, and quartz bowlders form a large part if not all of the streams gravels wherever exposed.

A few large quartz veins were noted in the bluffs near Ruby. One vein at least 15 feet wide is penetrated by an abandoned prospecting drift. Another vein about 6 feet wide 10 miles south of Ruby has been prospected, apparently without favorable results.

The quartz veins of the district are commonly iron stained on the surface. Hematite was noted in some of the vugs and pyrite and arsenopyrite in others. Arsenopyrite is probably the most abundant of the iron minerals. The quartz veins undoubtedly carry gold in the placer areas, for many nuggets containing quartz are found. Nuggets composed partly of hematite are also found, suggesting that the hematite vugs noted in the quartz veins may be auriferous.

Cassiterite, the oxide of tin, is found in the concentrates on Midnight Creek and probably is a phase of vein mineralization.

UNCONSOLIDATED DEPOSITS.

Practically the entire surface of the Ruby district is mantled by unconsolidated deposits. Gravels commonly occur as the lower part of the alluvium of the present valleys. High gravels have been discovered on top of the river bluffs near Ruby and at Skookum Bar, on a ridge at the head of Big Creek about 5 miles south of Ruby. Silts form a large part of the valley filling of the streams, especially near Yukon River, and may also form part of the upland mantle throughout the district. Residual clays are widespread in the whole region and cover much greater areas than either the silts or gravels. They mantle the lower hills and ridges and have crept down into the valleys. The gravels of the valley bottoms are covered as a rule by a considerable thickness of clay, much of which has come from the adjacent hillsides.

The alluvial deposits increase in depth downstream in all the valleys and are deepest in the trunk valleys and the valleys immediately tributary to them. They are exceptionally deep on the streams near the Nowitna and Solatna lowlands.

On White Channel Creek, a tributary of Trail Creek near its mouth, a shaft penetrated 45 feet of silt and 140 feet of gravel and did not reach bedrock. Seven miles upstream on White Channel Creek another shaft reached a depth of 182 feet without reaching bedrock and 7 miles farther upstream the alluvium is 60 feet deep.

On Long Creek the depth of alluvium ranges from 30 to 40 feet, at the farthest points tested upstream, to 70 feet 5 miles below the mouth of Bear Pup. The increase in depth is probably at a greater rate even farther downstream on Long Creek, for the bedrock slope of Midnight Creek is so much greater than the surface slope that the alluvium at the mouth of Midnight Creek must be considerably over 100 feet in depth.

In general the depth of alluvium corresponds rudely with the width of the valley. In the lower reaches of the Solatna and its tributary streams depths of over 100 feet are to be commonly expected, and depths of 200 feet and more should not be surprising at the border of the more extensive flats.

ECONOMIC GEOLOGY.

THE GOLD-BEARING STREAMS.

Gold placers are the only mineral deposits of the district of commercial value. Placer tin is found in small amounts with the gold on Midnight Creek.

Auriferous gravels have been discovered thus far only in the alluvial deposits of the present streams. The localities where gold is known to occur have been platted on the map (Pl. X) so far as data are available. The localities where the deposits have proved rich enough for mining are indicated by a special symbol. Though auriferous gravels are widely distributed in the district, those rich enough to support mining are limited to the valleys of Ruby Creek, Long Creek and its tributaries, Glen Gulch, and Trail Creek. Because of their greater importance the deposits of these streams will be described first.

RUBY CREEK.

The auriferous deposits of Ruby Creek are confined to a small area on a low bench on the right bank of the stream near its mouth. The alluvium is 12 to 15 feet deep and includes beds of large well-rounded bowlders, lenses of angular detritus, sands, and silts. The coarse materials of the deposit are composed of metamorphic and igneous rocks and vein quartz, all of which occur in the local bedrock. There are no unusual mining difficulties and a low gold tenor is apparently the cause of the scant production credited to the creek.

LONG CREEK AND TRIBUTARIES.

The valleys of Long Creek and its tributaries contain remnants of older alluvial deposits that stand considerably above the present flood plains of the streams. The bedrock floors of the valleys are practically level in cross section, so that the depth to bedrock in many localities increases away from the stream toward the valley wall. There is also a general increase in depth to bedrock downstream.

On upper Long Creek the auriferous deposits are 100 to 500 feet from the stream and are at a depth of 30 to 40 feet below the surface. The gold lies close to bedrock beneath a stratum of gravel 4 to 6 feet thick. The rest of the overburden is clay containing unworn brecciated vein quartz. The gold is coarse, being mostly in pieces worth from 50 cents to $10.

The valley of lower Long Creek has a more or less continuous pay streak extending at least 5 miles downstream from the mouth of Bear Pup. All the discoveries have been on the left side of the stream and for the most part at a considerable distance from it. It is about 50 feet to bedrock at the upstream end of the pay streak as represented in the Windy Bench claim. The depth increases to about 70 feet 5 miles below Discovery claim, although the surface of the alluvium at the latter locality is more nearly at the creek bottom level than it is on Windy Bench. The slope of the bedrock surface downstream is much greater than that of the present stream, and it is probable that the depth to bedrock will increase at least 10 feet to the mile below the last workings on Long Creek. In the upper claims the gold is pretty well concentrated on bedrock, but farther downstream the thickness of the auriferous stratum increases and in places 5 or 6 feet of gravel are hoisted and washed. The width of the deposit also increases downstream from 50 to more than 100 feet.

The gravels of Long Creek are nowhere known to be phenomenally rich, but there is apparently much ground that will yield from $1 to $3 per square foot of bedrock, or $10 to $15 per yard of material mined. The deposits are all frozen, so that timbering is rarely required in the workings. Economical methods of mining are possible that would permit ground yielding even less than $1 per square foot of bedrock surface to be worked at a profit.

The stream gravels of Bear Pup are auriferous for a distance of at least 2 miles above its mouth. The valley is narrow as compared with that of Long Creek, and the pay streak follows closely the course of the present stream. The older filling of the valley has been largely removed, so that the gravels are now only 6 to 12 feet deep. The upstream claims are on the shallower ground, which is mostly thawed. The width of the pay streak varies, but the maximum is about 15 feet and in some places the tenor of the gravels is probably quite as high as those of Long Creek. Open-cut methods are practicable along the entire creek, so that gravels of very low tenor are available for mining.

The gold-bearing gravels of Midnight Creek are like those of Long Creek in lying at considerable depth. About 2 miles above its mouth the depth to bedrock is 18 to 22 feet. A mile below this locality the depth is about 60 feet, and farther downstream probably still greater

depths will be encountered. The richest part of the deposit is not on bedrock but is between 6 and 8 feet above it. The stratum below that which carries most of the gold consists of large quartz, quartzite, and greenstone bowlders with the interstices filled with a stiff greenish clay. All the gravels are auriferous, but only the stratum between 6 and 8 feet above bedrock carries sufficient gold for mining, so far as known. This stratum probably represents a reconcentration of an older valley filling which was removed to a depth of a few feet above bedrock. Subsequently the valley was again aggraded to the present level of its floor. Workable deposits have been discovered on a single claim on Midnight Creek, but as only a small amount of prospecting has been done, it seems likely that more extensive deposits may be found in its valley.

GLEN GULCH.

The gravels of Glen Gulch are known to be gold bearing practically throughout its length, a distance of about 2½ miles. Some of the deposits have proved rich enough to encourage mining by the comparatively expensive method of drifting and hoisting the gravels to the surface by hand and by steam machinery. However, a large part of the placer ground will be available only for the more economical open-cut methods. This is especially true of the upper part of the creek, where the gravels are only 10 to 15 feet deep. The stream gravels deepen downstream to about 25 feet. Several prospecting shafts have been sunk about 50 feet to bedrock on a bench on the left side of the creek near its mouth, apparently without satisfactory results. All the deposits, except those very near the head of the stream, are frozen.

If further prospects should prove the existence of sufficiently large bodies of auriferous gravels to justify the project, water could be brought from Flint Creek, probably under sufficient head for hydraulic mining.

TRAIL CREEK.

Auriferous deposits rich enough to support mining have been discovered in the stream gravels of Trail Creek for a distance of about 2 miles along the valley. Gold prospects have been found farther down the valley for a distance of about 17 miles.

The valley filling is commonly a stratum of gravel on bedrock several feet thick, overlain by muck. The depth to bedrock on upper Trail Creek is about 40 feet. Seven miles down the valley it is 70 feet, and it probably continues to increase farther downstream. All the deposits are well frozen and adapted for drift mining. The gold occurs close to the bedrock, so that a minimum amount of hoisting is necessary in its recovery.

OTHER CREEKS.

Auriferous gravels are said to occur on a number of streams other than those where mining has been done.

On Tip Creek, which heads between Flint and Trail creeks in their lower courses, considerable prospecting has been done. The valley of Tip Creek is said to be broad and flat and the alluvium deep. Prospects rich enough to stimulate further work have been found in a few holes near its head.

Quartz Creek is the next large tributary of Solatna River above Trail Creek. Prospecting has been done on the main stream and several tributaries, and the outlook is said by those interested to be encouraging. The ground is 50 to 180 feet deep and, except in the deepest places, is frozen.

Several of the southerly tributaries of Solatna River have received attention from prospectors, who report encouraging prospects at a number of localities. Rather deep but well-frozen ground seems to be the rule on these streams.

MINING IN 1912.

In the Ruby district, in 1912, mining operations were in progress on six creeks, all located in a small area about 25 miles south of Ruby. Four of these creeks belong to the Long Creek system, namely, Long Creek, Upper Long Creek, Bear Pup, and Midnight Creek. The other two creeks are Glen Gulch, a tributary of Flint Creek, which heads against Bear Pup, and Trail Creek, which is the next creek east of Flint. On Long Creek below the mouth of Bear Pup nine claims were worked by as many plants using steam thawing and hoisting gear. About fifty men were employed most of the summer. Early in the summer several of the plants were prospecting rather than mining. Later reports indicate that considerable new ground yielding good returns was opened and that the whole summer witnessed a general improvement in results along the creek.

On Long Creek above the mouth of Bear Pup three outfits, employing about ten men in all, worked claims Nos. 2, 3, and 4 above Discovery. These plants used small prospecting boilers for thawing, running three or four points each. Hoisting was by hand windlass. Water for sluicing was obtained from Long Creek and carried to the claims by a ditch over 2 miles in length.

On Bear Pup five claims were worked by about thirty men. One plant used steam-hoisting gear to raise the gravel to the sluice boxes after the overburden had been groundsluiced off. The other four plants also used open-cut methods, groundsluicing the overburden and shoveling into the boxes. A large area on No. 1 Bear Pup was being stripped of vegetation preparatory to groundsluicing.

Considerable harm was done some of the workings by midsummer floods, but on the whole the Bear Pup operations were successful.

Only a single claim was worked on Midnight Creek by two men, who used a small prospecting boiler for thawing and a windlass for hoisting. An excellent ditch from the stream furnished abundant water for sluicing, and considering the equipment fine progress was made, apparently with good results.

On Glen Gulch six claims in all were worked. A steam-hoisting plant worked on the lower part of the creek. Upstream were four small plants using the usual prospecting type of boiler for thawing and the hand windlass. Near the head of the stream a claim was being worked by open-cut methods without machinery. Not all of these plants worked continuously throughout the summer. About twenty-five men in all were employed.

On Trail Creek seven claims were worked by three steam-hoisting plants and four plants with small thawing boilers and hand windlass. About thirty men were employed. Good progress was made by most of these outfits throughout the summer.

SUMMARY.

In all, thirty-one claims were worked in the Ruby district, employing a total of 150 men. On fourteen claims steam-hoisting plants were operated; on twelve claims hoisting was done by hand; and on five claims hand open-cut methods were employed.

Exact data regarding the amount of gold production of the district are not available, but the total was probably between $150,000 and $175,000.

GOLD PLACERS OF THE INNOKO-IDITAROD REGION.

By HENRY M. EAKIN.

FIELD WORK.

The Innoko-Iditarod region lies in west-central Alaska and embraces most of the upland area north of Kuskokwim River that is drained by Innoko and Iditarod rivers. The writer spent a month of the summer of 1912 in making a geologic reconnaissance of a part of the region after having made a similar survey of the Ruby district. (See pp. 279–292.)

This region was visited by Maddren in 1908 and again in 1910. His work[1] has contributed much information concerning parts of the region not visited by the writer and has aided in preparing the accompanying geologic sketch map. (See Pl. X, p. 280.)

The placer mines of the region are grouped in two rather distinct areas, known as the Innoko and Iditarod districts, respectively, corresponding in name with the rivers that drain them. Although the two mining districts have many points in common, they have also differences which make their separate treatment advisable.

INNOKO DISTRICT.

GEOGRAPHY.

LOCATION OF THE MINES.

The mining center of the Innoko district is about 75 miles southwest of that of the Ruby district. The principal gold placer mines are in the valleys of five neighboring streams that join Innoko River from the southwest. These, named in order, beginning with the farthest downstream, are Ophir, Spruce, Little, Gaines, and Yankee creeks. All excepting Gaines are only a few miles in length. At the mouth of Ophir Creek is the principal settlement of the district, called Ophir.

A locality about 25 miles northeast of Ophir has been the scene of recent discoveries of placer gold on the headwaters of Colorado Creek, which is tributary to Innoko River. The chief discovery is on a

[1] Maddren, A. G., The Innoko gold-placer district, Alaska: U. S. Geol. Survey Bull. 410, 1910; Gold placer mining developments in the Innoko-Iditarod region: U. S. Geol. Survey Bull. 480, pp. 236–270, 1911.

stream called Cripple Creek, at the mouth of Fox Gulch. These streams head in a small group of prominent mountains about 3,500 feet high. Practically all the streams heading in this mountain group are said to carry some placer gold, but their true value is not evident from the small amount of prospecting that has been done.

Near the divide between Gaines and Yankee creeks, at the head of Carter Creek, is a gold lode mine, the only one in the district.

RELIEF.

The Innoko district is, in general, a rolling country with here and there a group of prominent mountains 3,000 to 4,500 feet high. The three principal mountain groups are the Cripple Creek Mountains at the head of Colorado Creek, the Twin Mountain group 10 miles east of Ophir, and the Beaver Mountains 20 miles southwest of Ophir. Each of these groups is a topographic expression of granitic intrusions and the rocks affected by them.

The topography of the lower rolling country of the district is closely dependent on the structure of the sedimentary rocks that form it. Between the Cripple Creek and Twin Mountains the structure is simple. This area is marked by hogback ridges that break off sharply on one side and have long dip slopes on the other. The valleys are broad and widely spaced and conform to the structural trends of the bedrock. Near Ophir the dips are higher and the interstream ridges are comparatively narrow and steep sided. The influence of structure upon topography is especially evident in the valley of Spruce Creek. The stream follows a straight course on the line of strike of the bedrock. The bedrock dips westward and in its downcutting the stream has migrated in that direction. The west valley wall is now a steep scarp along the base of which the stream runs. The opposite side of the valley slopes gently upward away from the stream over a series of gravel-covered benches. The chief gold concentration in the valley antedates the latest rejuvenation of the stream. Consequently the placers are found in the bench gravels along the east side of the valley up the dip from the stream, and little gold is to be expected in the stream itself.

An effect of structure similar to that seen in the form of Spruce Creek valley can be noted at places on the other streams of the district. It should be borne in mind that in downcutting the stream shifts its position in the direction of the dip, that in such localities gold concentrations are most likely to occur in the gravel benches of the broadly open side of the valley, and that where dips are vertical, or nearly so, lateral shifting of the stream does not occur and any concentrations will be found in the present gravels of the stream.

A set of topographic features of exceptional type has been developed by glaciation in the Beaver Mountains and vicinity, as described

by Maddren.[1] The mountain valleys were given a broad U-shaped form and the adjacent depressions were filled with morainic débris. Drainage lines were altered, the basin of Gaines Creek obtaining considerable area that formerly drained into Beaver Creek. In the adjustment of Gaines Creek to the new conditions a box canyon was cut through the old divide and a lower grade established in its lower course, giving rise to extensive stream terraces.

GENERAL GEOLOGY.

CHARACTER OF THE ROCKS.

By far the greater part of the Innoko district is underlain by a series of Mesozoic sedimentary rocks, probably for the most part of Cretaceous age. They are locally interbedded with basic igneous rocks. Older rocks, including cherts, schists, and limestones, probably of Paleozoic age, occupy certain areas north of the Cripple Creek Mountains and at a locality 15 miles northwest of Ophir. Granites and kindred types of igneous rocks are common to the mountainous areas. Rhyolitic dikes closely related to the granite intrusives are generally distributed throughout the region.

Unconsolidated deposits, including stream gravels, terrace gravels, and glacial and glaciofluviatile deposits occur in the lowland areas. The general distribution of the different formations is shown on the map (Pl. X, p. 280).

VEINS AND MINERALIZATION.

The chief development of veins and mineralization is in the granite and rhyolite dikes that intrude the Cretaceous rocks. The structure of these rocks is in many places complex and their history obscure. However, the later processes affecting such dikes apparently accompanied their invasion by mineralizing solutions, which in some places formed auriferous quartz veins and marked profound changes in the composition of the dikes and their walls. The mineral introduced most abundantly besides quartz is iron carbonate, which makes up a large percentage of some of the dikes and the adjacent altered sedimentary rocks. In some localities the altered dike rock is made up almost entirely of iron carbonate and secondary quartz about equally divided in amount. The original character of the rock is shown by partly resorbed phenocrysts of quartz and pseudomorphs of iron carbonate after the feldspars.

These altered dikes have an important economic bearing, as some of the quartz veins which cut them are known to carry free gold, and they are apparently directly related to rich placer accumulations at several localities.

[1] Maddren, A. G., The Innoko gold-placer district, Alaska: U. S. Geol. Survey Bull. 410, pp. 13–14, 1910.

Veins of pure quartz and of iron carbonate cut the sedimentary series in places independently of the igneous dikes, and they also may have a bearing on the auriferous mineralization.

UNCONSOLIDATED DEPOSITS.

The unconsolidated deposits of the Innoko district include stream gravels, terrace gravels, and glacial and glaciofluviatile deposits. The stream gravels are of normal type and distribution, flooring the valleys, which in general are of medium width, to depths of 10 to 30 feet. The terrrace gravels are developed chiefly along Gaines Creek, owing to the enlargement and rejuvenation of the stream through glacial activity. The terraces increase in elevation upstream on Gaines Creek to the locus of the preglacial divide, where they disappear. Terraces also occur on Little, Spruce, and upper Ophir creeks. These creeks have probably felt a slight rejuvenation due to the increase in size of Gaines Creek and Innoko River above the mouth of Beaver Creek. In the consequent downcutting of their channels the bedrock structure has caused a lateral shifting of the streams, and the former stream gravels now form terraces slightly above the present stream levels.

The glacial and glaciofluviatile deposits are developed chiefly about the Beaver Mountains. The longest glaciers left their terminal moraines probably 5 or 6 miles from the center of the range or about 2 miles from its edge. The older topography has been obliterated by the deposition of material furnished by the glaciers, so that the mountains are now bordered largely by broad gravel plains. The buried topography probably had considerable relief and there must be a corresponding variation in the depths of the glacial deposits.

AURIFEROUS GRAVELS.

Workable deposits of auriferous gravels have been discovered so far only on Ophir, Spruce, Little, Gaines, and Yankee creeks. Gold prospects are said to occur on a number of other streams in the vicinity of the mines. During the summer of 1912 discoveries of placer gold were made on a number of streams heading in the Cripple Creek Mountains. The richest gravels discovered in this locality are on Cripple Creek at the mouth of Fox Gulch and on the headwaters of Colorado Creek.

Ophir Creek has been the chief producer of the Innoko district for a number of years, but its gravels are about exhausted at the present time. The gravels in the lower part of the valley are about 30 feet deep, their depth decreasing upstream to 20 feet at claim No. 6 above Discovery, where a bedrock bench about 7 feet above the top of the stream gravels is covered by 10 feet of gravels. Some open-

cut work has been done on this bench ground, but downstream all the mining has been done by drifting. Ophir Creek has furnished some good mining ground, claim No. 3 below Discovery, considered the best, having produced over $200,000.

Spruce Creek has workable ground only on the benches along its right slope. The benches carry from 2 to 6 feet of gravel covered by 10 to 15 feet of frozen muck. Two claims have been opened up so far. But little is known of the tenor of the gravels farther downstream, where the bench continues for several claim lengths.

On Little Creek auriferous gravels are found beneath the present stream and on benches. The benches are best developed along the middle section of the course of the streams and where widest extend about 500 feet from the creek. On the upper and lower parts of the creek the pay streak is relatively narrow and is confined to the course of the creek. The bench ground and lower creek claims are workable by open-cut methods. The claims farthest upstream have 18 to 30 feet of gravel and are mined by drift methods. Where the benches are widest a width of 300 feet is said to carry sufficient gold for profitable mining.

Gaines Creek has a pronounced development of gravel-covered benches along the right side of the valley and, below the canyon, a rather broad gravel flood plain. Gold occurs in the gravels of both types of deposits, but so far only the bench gravels have proved available for mining. It seems likely that the flood-plain gravels may contain fairly high values in places, but their prospecting is difficult because of their thawed condition.

The original concentration of gold in the Gaines Creek valley occurred in the preglacial time, when the stream was much shorter and had less volume. Apparently a continuous pay streak was formed at that time, which extends for miles along the stream. When the stream was rejuvenated part of the old pay streak was carried down and reconcentrated at the present stream level and should be found in the flood-plain gravels in the reaches between the gold-bearing benches. Parts of the original concentration remain in the bench gravels. Where lateral streams cross the course of the old pay streak they have concentrated its gold from the width of the tops of their recently cut valleys to the narrow gravel deposits in their bottoms. This form of reconcentration has probably given some of the richest spots of the Gaines Creek valley.

The Gaines Creek placers have been worked almost entirely by open-cut methods. Water for sluicing is taken from the small tributaries of Gaines Creek and in many places work has progressed slowly on account of the small supply. The bench gravels are nearly worked out at the present time and the future of Gaines Creek as a producer will depend largely upon the availability of the flood-plain

gravels. If systematic prospecting should prove their worth these gravels would be admirably adapted for dredging.

The Yankee Creek placers are all in shallow stream gravels and extend along the stream for at least three claim lengths. They are worked by groundsluicing the overburden and either hoisting the auriferous material by machinery or shoveling it directly into the sluice boxes.

GOLD LODES.

The sedimentary rocks of the Innoko district are cut here and there by fine-grained granitic and rhyolitic dikes, many of which are more or less mineralized. In several places they are cut by auriferous quartz veins, at least one of which constitutes a workable lode deposit—that being worked near the head of Carter Creek, an eastern tributary of Gaines Creek. The ore body is a quartz vein averaging about 2 feet in thickness along the hanging wall of a rhyolite dike intrusive in the sedimentary series. Under the microscope the gold is seen to occur along iron-stained crevices and in vugs and also within small bodies of magnetite in the quartz vein. Veinlets of iron carbonate cut the quartz vein, and iron carbonate is abundantly present in the altered sedimentary rock on the one hand and in the altered dike on the other. In many specimens the alteration has been so profound as to entirely obscure the original character of the rock, resulting in a type composed almost entirely of secondary quartz and iron carbonate.

The lode has been prospected by a tunnel and two drifts at lower levels connected with the tunnel by a slightly inclined winze. The workings show the vein to be continuous to a depth of 90 feet below the surface and there are no evident geologic reasons why it should not continue to many times that depth.

Several other mineralized dikes and quartz veins have been located as mining properties within a few miles of the Carter Creek mine and very favorable assays are said to have been obtained of samples taken from them. The same type of mineralization as that at the mine is common over a large part of the Innoko district and the general geologic conditions are favorable to the occurrence of gold lodes of value.

MINING IN 1912.

GOLD PLACERS.

No new creeks were added to the list of producers in 1912. Operations were continued on Ophir, Spruce, Little, Gaines, and Yankee creeks, but the ratios of their production are considerably different from those of previous years. Ophir Creek fell off in production, owing to the fact that most of the available ground is exhausted. Little Creek largely increased its output, mainly owing to the dis-

covery of rich bench ground admirably situated for rapid mining. The other streams continued about as before.

Ophir Creek.—Five claims were worked on Ophir Creek by the same number of plants, all equipped with steam machinery. A total of 25 men worked on this creek most of the summer.

Spruce Creek.—Two bench claims were worked on Spruce Creek by open-cut methods. A ditch from the upper course of the creek delivers an excellent supply of water to the claims for groundsluicing. By this method the overburden of muck and lighter gravels are removed. The remaining gravels are then shoveled by hand into the sluice boxes. In all 13 men were employed.

Little Creek.—Both the stream gravels and bench deposits were worked on Little Creek. Operations were in progress on five claims and a total of 26 men was employed. Especially good progress was made on the bench claims and lower creek claims where open-cut methods are in use.

Gaines Creek.—Only the bench claims on Gaines Creek and the reconcentrations in the valleys of side streams near their mouths were worked. A large proportion of the available ground of this character was exhausted during the summer. Ten claims were worked in all by a total force of about 50 men.

Yankee Creek.—Two groups of claims were worked on Yankee Creek by two plants, both using open-cut methods. About 25 men in all were employed.

Summary.—In all 24 claims, located on five creeks, were worked in the Innoko district in 1912 by a total force of about 140 men. Eighteen plants used open-cut methods, and six used steam machinery in hoisting from drifts. The total value of the placer-gold production for the year was probably in excess of $250,000.

LODE MINING.

A single gold lode mine was operated near the head of Carter Creek, an eastern tributary of Gaines Creek. The work consists of a 60-foot tunnel, a 60-foot winze driven at its end, and two drifts of about 50 feet and 30 feet, respectively, at two lower levels. The equipment includes a 12-horsepower engine and boiler, and a "Little Giant" crusher and stamp mill. On the average five men are employed.

IDITAROD DISTRICT.

GEOGRAPHY.

LOCATION OF THE MINES.

The mining center of the Iditarod district is about 75 miles southwest of that of the Innoko district on a group of streams belonging to the Iditarod River system. The most important mines are on Otter Creek and on Flat Creek, its chief southern tributary. A num-

ber of smaller streams adjacent to Flat Creek or heading in the same mountain mass support mining or show excellent prospects. Among these are Glen Gulch and Black Creek, of Otter Creek drainage; Chicken, a tributary of Bonanza; Willow Creek, a tributary of Iditarod River; and Happy Creek, the chief tributary of Willow. There is also a placer mine on Moore Creek, which heads against Otter, about 30 miles east (Pl. X, p. 280).

TOPOGRAPHY.

The topography of the Iditarod district is similar to that of the Innoko in many respects. The general relief is low, and topographic forms are controlled largely by geologic structure. The highest elevations are developed in the regions of igneous intrusions in the sedimentary rocks, notably in the vicinity of the Otter Creek mining center. The larger streams, however, have much broader flats in proportion to their size than have those of the Innoko district, owing to their closer proximity to the trunk streams of this section of Alaska, which have aggraded their valleys extensively in recent geologic time.

CONDITIONS AFFECTING MINING.

What has been said of the climate, forests, and vegetation, fish, and game of the Innoko district applies equally well to the Iditarod district. The water supply in drainage basins of equal size would be about the same. However, the situation of the Iditarod mines gives rise to special problems of water supply, some where an excess of water must be dealt with and others where a scant supply is gained by artificial collecting channels near the mountain tops.

SETTLEMENTS AND POPULATION.

The district has three principal settlements: Iditarod at the head of steamboat navigation on Iditarod River, Flat at the mouth of Flat Creek, and Discovery on Otter Creek. Recent changes in methods of mining and ownership in the district have occasioned a considerable loss in population. At present Iditarod has an average population of about 500, Flat of about 300, and Discovery of about 50, exclusive of the miners. It is estimated that about 975 men are employed in mining in the district, bringing the total population to over 1,800.

TRANSPORTATION.

Supplies reach the Iditarod district by steamboats plying Innoko and Iditarod rivers. The head of navigation in good stages of the water is Iditarod. There is a tramway in operation between Iditarod

and Flat. Wagon roads have been built from Iditarod and Flat to all the important mines. The road on Flat Creek is especially good, having been fitted for hauling heavy dredge machinery. Moore Creek receives supplies from Discovery over a pack trail.

GENERAL GEOLOGY.

CHARACTER OF THE ROCKS.

The Iditarod district is underlain chiefly by sedimentary rocks, apparently a continuation of the series occurring in the Innoko district (Pl. X, p. 280). Here, too, there are basic igneous rocks interbedded with the sedimentary members, and the series is intruded by granitic batholiths and lenticular sills and by a variety of dikes. Westward, in the vicinity of Iditarod, the area of sedimentary rocks is bordered by metamorphic rocks, including schists, limestones, and cherts. The valleys are floored by the usual stream gravels of moderate depth. There are no true terrace gravels known in the district, but there are elevated residual deposits that locally are of economic importance.

VEINS AND MINERALIZATION.

Quartz veins in great abundance but generally of small size cut both the sedimentary and the igneous rocks of the district. Some of those in each situation are auriferous. Some of the veins carry, besides gold, considerable amounts of cinnabar and stibnite.

The availability of any of the veins as minable lodes has not been demonstrated as yet. However, little attention has been paid to this form of deposit and further prospecting may reveal auriferous veins of sufficient size for mining, or stockworks of small closely spaced veinlets in the monzonites or along their contacts rich enough to work. The local richness of some of the residual placers on the hill at the head of Flat, Chicken, and Happy creeks supports this view, but it can be established only by actual tests of the bedrock along the zones of more abundant mineralization.

UNCONSOLIDATED DEPOSITS.

All the unconsolidated deposits of the district revealed by placer-mine operations are of medium or shallow depth and are workable by open-cut methods. They are of two general types—stream gravel deposits of the valley bottoms and residual mantle deposits on slopes and even hilltops, apparently unrelated to drainage lines. No true terrace deposits have been discovered.

The stream gravel deposits range from 10 to 18 feet in depth, including in places a slight overburden of muck. The width of the

deposits corresponds in normal fashion to the size of the streams. The pay streaks are much narrower than the total width of the valley, showing that the first downcutting of the valleys was followed by a long period of erosion under stable conditions during which the present flood plains were formed. At present the valleys are probably aggrading slightly in adjustment to the change of base level that has occasioned the enormous filling of the lower Iditarod and Innoko valleys.

Residual mantle deposits are widespread in the district, but only that covering the slopes and hilltops at the heads of Flat, Chicken, and Happy creeks is of special importance. At this locality a deposit ranging from a few feet to 20 feet in depth has been developed by the weathering of the monzonite batholith and associated rocks.

The igneous rock weathers first along the joint planes, and as the process continues large spheroidal masses are produced, separated from each other by disintegrated rock. Accompanying this action more or less creeping of the loosened materials on the slopes occurs and water action has some effect in removing the finer particles.

The long-continued action of these processes in the Iditarod district has produced residual bowlders that in form illustrate all stages in the transformation of the angular blocks of bedrock to spheroidal forms of small size. Mixed with the monzonite bowlders are weathered fragments of other types of rocks that have crept down from the hilltop above. The interstices are filled with granular sands and angular fragments of quartz stringers. The removal of the sands at the surface has caused in places a concentration of the bowlders.

In the auriferous deposits of this character the gold is distributed throughout the vertical range of the disintegrated materials, and it is not always possible to foretell the locus of maximum concentration. As a rule, however, the richest deposits are near the solid bedrock surface.

MINING IN 1912.

Character of the auriferous deposits.—The general character and distribution of the auriferous deposits have been indicated in the preceding section. There is little variation in the essential character of the deposits of the same type, and the general descriptions may be taken as applying specifically to the various individual placers. It should be stated that stream gravels furnish the placers of Otter, Flat, Willow, lower Happy, and Moore creeks, and the residual deposits those at the heads of Flat, Chicken, and Happy creeks (Pl. X, p. 280).

Producing creeks.—Otter and Flat creeks were the largest producers in 1912, as in previous years, the production of the former being slightly greater than that of the latter. Happy, Glen Gulch, Willow, and Black creeks in the same neighborhood and Moore Creek,

30 miles to the east, all report considerable production. Systematic prospecting was done on the head of Chicken Creek, but little actual mining was accomplished.

Otter Creek.—Three claims were worked on Otter Creek, leased in small tracts to 10 operators. Heavy steam machinery was used in open-cut work. About 450 men in all were employed.

Flat Creek.—The year 1912 witnessed a great change in the mining operations on Flat Creek, owing to the extensive purchase and leasing of ground by the Yukon Gold Dredging Co. A great number of plants discontinued work, and there was a great reduction in the number of men employed.

The Yukon Gold Dredging Co. installed a dredge on the Marietta group of claims, near the head of the creek. It began operating the last of August and continued until near the freeze-up.

Eight other creek claims were worked by steam plants, using open-cut methods and hoisting in buckets to the sluice boxes. On the hillside above the head of Flat Creek five claims were worked by five plants, groundsluicing and shoveling into the sluice boxes being the method used. A total of about 400 men were employed.

Happy Creek.—Five claims were worked on Happy Creek, two of them being on creek placers and the others on ground of the residual placer type. All used open-cut methods without steam machinery. About fifty men were employed.

Glen Gulch.—The operations on Glen Gulch were confined to the early part of the season. A considerable production is reported for this creek, but the work was discontinued before the end of the season, owing to the exhaustion of available placer ground.

Willow Creek.—Two claims were worked on Willow Creek by two plants. About twenty men in all were employed. A prospecting drill was in use on Willow Creek most of the summer.

Black Creek.—A single plant worked on Black Creek part of the summer. No details of the operations are available.

Moore Creek.—One claim was operated on Moore Creek by a single plant that employed twelve men. The ground is shallow and work is done by hand methods.

Chicken Creek.—Systematic prospecting with a drill was done on Chicken Creek during the summer, and a little mining was done. Two plants were operating part of the time. In all, twelve men were employed.

Summary.—Twenty-nine claims, located on eight different creeks, were worked in the Iditarod district in 1912. Thirty-six plants were engaged in the work. Of these one was a dredge, 22 were equipped with steam machinery, and 13 used hand methods. A total of about 975 men were employed. The value of the total gold production of the district, including Moore Creek, for the year was probably about $2,750,000.

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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:

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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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*The geography and geology of Alaska, a summary of existing knowledge, by A. H. Brooks, with a section on climate, by Cleveland Abbe, jr., and a topographic map and description thereof, by R. U. Goode. Professional Paper 45, 1906, 327 pp. $1.

*Placer mining in Alaska in 1904, by A. H. Brooks. In Bulletin 259, 1905, pp. 18–31. 15 cents.

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*The mining industry in 1911, by A. H. Brooks. In Bulletin 520, 1912, pp. 19–44. 50 cents.

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*Railway routes from the Pacific seaboard to Fairbanks, Alaska, by A. H. Brooks. In Bulletin 520, 1912, pp. 45–88. 50 cents.

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*Notes on the petroleum fields of Alaska, by G. C. Martin. In Bulletin 259, 1905, pp. 128–139. 15 cents.

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*The possible use of peat fuel in Alaska, by C. A. Davis. In Bulletin 379, 1909, pp. 63–66. 50 cents.
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*The distribution of mineral resources in Alaska, by A. H. Brooks. In Bulletin 345, pp. 18–29. 45 cents.
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*Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. Bulletin 263, 1905, 362 pp. 35 cents. (Abstract in *Bulletin 259, 1905, pp. 32–46. 15 cents.)
*Prospecting and mining gold placers in Alaska, by J. P. Hutchins. In Bulletin 345, 1908, pp. 54–77. 45 cents.
*Geographic dictionary of Alaska, by Marcus Baker; second edition prepared by James McCormick. Bulletin 299, 1906, 690 pp. 50 cents.

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*Map of Alaska showing contours; scale, 1:2,500,000; preliminary edition; by R. U. Goode. In *Professional Paper 45. $1. Not issued separately.
*Map of Alaska showing distribution of mineral resources; scale, 1:5,000,000; by A. H. Brooks. In *Bulletin 345. 45 cents. Not issued separately.
Map of Alaska; scale, 1:5,000,000; by Alfred H. Brooks. 20 cents.
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*The Porcupine placer district, Alaska, by C. W. Wright. Bulletin 236, 1904, 35 pp. 15 cents.
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*Economic developments in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin 259, 1905, pp. 47–68. 15 cents.
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*Copper deposits on Kasaan Peninsula, Prince of Wales Island, by C. W. Wright and Sidney Paige. In Bulletin 345, 1908, pp. 98–115. 45 cents.
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*The Yakutat Bay region, Alaska: Physiography and glacial geology, by R. S. Tarr; Areal geology, by R. S. Tarr and B. S. Butler. Professional Paper 64, 1909, 186 pp. 50 cents.
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*Juneau gold belt, Alaska; scale, 1:250,000; compiled. In *Bulletin 287. 75 cents. Not issued separately.
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*The mineral resources of the Mount Wrangell district, Alaska, by W. C. Mendenhall. Professional Paper 15, 1903, 71 pp. 30 cents.
*Bering River coal field, by G. C. Martin. In Bulletin 259, 1905, pp. 140–150. 15 cents.
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Petroleum at Controller Bay, by G. C. Martin. In Bulletin 314, 1907, pp. 89–103.
Geology and mineral resources of Controller Bay region, Alaska, by G. C. Martin. Bulletin 335, 1908, 141 pp.
*Notes on copper prospects of Prince William Sound, by F. H. Moffit. In Bulletin 345, 1908, pp. 176–178. 45 cents.
*Mineral resources of the Kotsina and Chitina valleys, Copper River region, by F. H. Moffit and A. G. Maddren. In Bulletin 345, 1908, pp. 127–175. 45 cents.
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*Copper mining and prospecting on Prince William Sound, by U. S. Grant and D. F. Higgins, jr. In Bulletin 379, 1909, pp. 87–96. 50 cents.
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*Mining in the Kotsina-Chitina, Chistochina, and Valdez Creek regions, by F. H. Moffit. In Bulletin 379, 1909, pp. 153–160. 50 cents.
*Mineral resources of the Nabesna-White River district, by F. H. Moffit and Adolph Knopf. In Bulletin 379, 1909, pp. 161–180. 50 cents.
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*Gold deposits near Valdez, by A. H. Brooks. In Bulletin 520, 1912, pp. 108–130. 50 cents.
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The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp.
*Coal resources of southwestern Alaska, by R. W. Stone. In Bulletin 259, 1905, pp. 151–171. 15 cents.
*Gold placers of Turnagain Arm, Cook Inlet, by F. H. Moffit. In Bulletin 259, 1905, pp. 90–99. 15 cents.
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*A reconnaissance of the Matanuska coal field, Alaska, in 1905, by G. C. Martin. Bulletin 289, 1906, 36 pp. 25 cents.

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*Notes on geology and mineral prospects in the vicinity of Seward, Kenai Peninsula, by U. S. Grant. In Bulletin 379, 1909, pp. 98–107. 50 cents.

Preliminary report on the mineral resources of the southern part of Kenai Peninsula, by U. S. Grant and D. F. Higgins. In Bulletin 442, 1910, pp. 166–178.

Outline of the geology and mineral resources of the Iliamna and Clark lakes region, by G. C. Martin and F. J. Katz. In Bulletin 442, 1910, pp. 179–200.

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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, 1911, 234 pp.

A geologic reconnaissance of the Iliamna region, Alaska, by G. C. Martin and F. J. Katz. Bulletin 485, 1912, 138 pp.

Geology and coal fields of the lower Matanuska Valley, Alaska, by G. C. Martin and F. J. Katz. Bulletin 500, 1912, 98 pp.

*Gold deposits of the Seward-Sunrise region, Kenai Peninsula, by B. L. Johnson. In Bulletin 520, 1912, pp. 131–173. 50 cents.

*Gold placers of the Yentna district, by S. R. Capps. In Bulletin 520, 1912, pp. 174–200. 50 cents.

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Preliminary report on a detailed survey of part of the Matanuska coal fields, by G. C. Martin. In Bulletin 480, 1911, p. 135.

A reconnaissance of the Willow Creek gold region, by F. J. Katz. In Bulletin 480, 1911, p. 152.

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Matanuska and Talkeetna region, reconnaissance map; scale, 1:250,000; by T. G. Gerdine and R. H. Sargent. In Bulletin 327. Not issued separately.

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Yentna district, reconnaissance map; scale, 1:250,000; by R. W. Porter. In Professional Paper 70. Not issued separately.

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Mount McKinley region, reconnaissance map; scale, 1:625,000; by D. L. Reaburn. In Professional Paper 70. Not issued separately.

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Kenai Peninsula, reconnaissance map; scale, 1:250,000; by R. H. Sargent, J. W. Bagley, and others.

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SOUTHWESTERN ALASKA.

REPORTS.

*Gold mine on Unalaska Island, by A. J. Collier. In Bulletin 259, 1905, pp. 102–103. 15 cents.

*Gold deposits of the Shumagin Islands, by G. C. Martin. In Bulletin 259, 1905, pp. 100–101. 15 cents.

*Notes on the petroleum fields of Alaska, by G. C. Martin. (Abstract from Bulletin 250.) In Bulletin 259, 1905, pp. 128–139. 15 cents.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp.

*Coal resources of southwestern Alaska, by R. W. Stone. In Bulletin 259, 1905, pp. 151–171. 15 cents.

The Herendeen Bay coal fields, by Sidney Paige. In Bulletin 284, 1906, pp. 101–108.

*Mineral resources of southwestern Alaska, by W. W. Atwood. In Bulletin 379, 1909, pp. 108–152. 50 cents.

Geology and mineral resources of parts of Alaska Peninsula, by W. W. Atwood. Bulletin 467, 1911, 137 pp.

Outline of the geology and mineral resources of the Iliamna and Clark lakes region, by G. C. Martin and F. J. Katz. In Bulletin 442, 1910, pp. 179–200.

A geologic reconnaissance of the Iliamna region, Alaska. Bulletin 485, 1912, 138 pp.

Mineral deposits of Kodiak and the neighboring islands, by G. C. Martin. In Bulletin 542, pp. 125–136.

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*Kuskokwim River and Bristol Bay region; scale, 1:625,000; by W. S. Post. In Twentieth Annual Report, *pt. 7. $1.80. Not issued separately.

YUKON BASIN.

*The coal resources of the Yukon, Alaska, by A. J. Collier. Bulletin 218, 1903, 71 pp. 15 cents.

*The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, Alaska, by L. M. Prindle. Bulletin 251, 1905, 89 pp. 35 cents.

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*The Fairbanks and Rampart quadrangles, Yukon-Tanana region, Alaska, by L. M. Prindle, with a section on the Rampart placers, by F. L. Hess, and a paper on the water supply of the Fairbanks region by C. C. Covert. Bulletin 337, 1908, 102 pp. 25 cents.

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*Water supply of the Fairbanks district in 1907, by C. C. Covert. In Bulletin 345, 1908, pp. 198–205. 45 cents.

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