MINING DEVELOPMENTS IN THE MATANUSKA COAL FIELD.

By Theodore Chapin.

INTRODUCTION.

The following report is based on several weeks' field work done at different times during the summer and fall of 1918 and includes developments up to the end of 1918.

The Matanuska coal fields are in the valley of Matanuska River, a tributary of Cook Inlet from the Talkeetna and Chugach mountains. This region has a special interest on account of the control and operation of two coal mines at Eska and Chickaloon which are being developed by the Department of the Interior through the Alaskan Engineering Commission.

The coal mines of the Matanuska Valley are from 50 to 75 miles from the town of Anchorage, which was established in 1915 as divisional headquarters for the railroad and as a shipping point and landing point for construction material. Anchorage was at first known as Ship Creek, the name of the stream on which it is built. It is on Knik Arm, a branch of Cook Inlet, and is opposite Knik Anchorage, the head of steam navigation for ocean-going steamers on Cook Inlet. Anchorage is the nearest point on the seacoast from which the Matanuska coal can be shipped, and is now connected by rail with the town of Seward. Under natural conditions Knik Arm is considered a closed port during four or five months of the year on account of the ice in the inlet. Engineers of the Alaskan Engineering Commission who have made a special study of ice conditions on Knik Arm believe, however, that these difficulties can be overcome and that terminal facilities and docks now under construction will make Anchorage an open port for ocean-going vessels for a larger part of the year.

The coal mines are served by the Matanuska branch, a spur of the Government railroad now under construction from Seward, on the Pacific seacoast, to the interior. The Matanuska branch leaves the main line at Matanuska, 37 miles from Anchorage. From Matanuska it is 38 miles to Chickaloon, the terminus of the spur. Construction work on the road toward the mines was started at Anchorage in May, 1915. Steel was laid to Moose Creek in August, 1916, and was completed to Chickaloon in October of the following year.

The geology of the coal fields of the Matanuska Valley is best known from the writings of G. C. Martin, who first visited the region in 1905 and made a general reconnaissance. In 1910 and 1913 Mr. Martin and his associates made more detailed studies of the lower part [1] and the upper part,[2] respectively, of the Matanuska coal fields. The work of 1910 is of the most interest in this connection, as it covered the region in which the productive mines are situated. In the report on this work the general geologic features of the lower Matanuska Valley are recorded, with as many details of the structure and stratigraphy of the coal-bearing rocks as it was possible at that time to get. In 1917 Mr. Martin again visited this region in a short trip to Eska and Chickaloon, and in the fall of 1918 he stopped over for a conference with members of the Alaskan Engineering Commission, Mr. Sumner S. Smith, and the writer regarding coal-mining problems.

The purpose of this report is to describe developments in the field and to record some recently acquired knowledge of the structure and stratigraphy of the coal-bearing rocks and the character and persistence of the coal beds, details of which are becoming more apparent with the opening of the underground workings.

The writer is indebted to Sumner S. Smith and George W. Evans, of the Bureau of Mines, for additional geologic data gathered by them incidental to the subdivision of the field into leasing units and to coal-mining operations. Detailed geologic information on the structure, assembled and mapped since the Alaskan Engineering Commission took over the operation of the coal mines, was placed at the disposal of the writer by Mr. Smith, resident engineer at the mines, who also cooperated and furthered the geologic work in every possible way.

The Geological Survey is further indebted to Mr. William C. Edes, commissioner, and to Mr. William Gerig, engineer in charge of the Alaskan Engineering Commission; to Mr. W. A. Gompertz, of the Chickaloon Coal Co., Mr. Henry Baxter, of the Matanuska Coal Co., and a number of others, including the mine superintendents and foremen.

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, 1912.

[2] Martin, G. C., and Mertie, J. B., jr., Mineral resources of the upper Matanuska and Nelchina valleys: U. S. Geol. Survey Bull. 592, pp. 273–299, 1914.

GEOLOGY.

STRATIGRAPHY.

The coal-bearing rocks of the lower Matanuska Valley all occur within the Chickaloon formation, a series of shale and arkosic sandstone with intercalated conglomerate and grits estimated to be at least 5,000 feet thick. These overlie a formation consisting almost entirely of arkose. Overlying the Chickaloon formation with apparent conformity is the Eska conglomerate, a formation composed essentially of massive conglomerate with a little sandstone.

The Chickaloon formation has yielded an abundant Kenai flora and is thus regarded as upper Eocene and correlated with a part of the coal-bearing Kenai formation of Cook Inlet. The underlying arkose is also probably Eocene. The Eska conglomerate is Eocene or Miocene. On the north side of Matanuska Valley the arkose rests unconformably upon the eroded surface of the granite. At a number of localities the arkose is faulted against Cretaceous and Jurassic sediments, and no doubt in places it unconformably overlies these older sediments, which show a greater degree of metamorphism than the Tertiary rocks and whose deposition is therefore believed to have been followed by a period of deformation.

The coal occurs within the Chickaloon formation, which contains a number of coal-bearing beds. Their number, stratigraphic position, and persistence are not well known. One coal-bearing bed appears to lie near the top of the formation, just below the Eska conglomerate. Beds of coal occur at about this horizon on Moose Creek and on a tributary of Eska Creek, a mile west of the Eska mine.

The coal of the Eska mine occurs at a somewhat lower horizon and possibly close to the Cretaceous sediments, but at this place part of the Chickaloon beds are probably cut out by faulting, so that the base of the formation is not present.

At Chickaloon the coal occurs well down in the formation. Below the coal horizon there is a known thickness of at least 2,000 feet, and between the coal and the Eska conglomerate there is probably a greater thickness.

The persistence of the individual coal beds or of groups of beds is not known. Locally both the coal beds and the inclosing strata vary greatly in size and character along the strike, especially at Chickaloon, as shown in the later discussion, and probably in a general way through the entire region. At Eska the coal beds appear to be fairly persistent, but the inclosing rocks vary considerably from place to place. For this reason it is not possible to correlate the coal beds over a great distance. This habit of rapid change in the thickness is due primarily to the original lenticular character of the sediments, but possibly it is due also in part to the crumpling and pinching out of the soft shales incident to the folding of the region.

INTRUSIVE ROCKS.

The Tertiary sediments are invaded by felsitic and basic rocks, including granite and diorite porphyry, diabase, and gabbro. In the coal areas the felsitic rocks are mostly in the form of sills and follow the bedding planes of the sediments. The diabase and gabbro are more laccolithic in form and occur as roughly lenticular masses which have domed the strata and sent out sills and dikes into the adjacent rock. These intrusive rocks show a tendency to seek out the soft shale and the coal, which locally may be improved in chemical character by the effect of the intrusive rock but is more likely to be destroyed or injured.

STRUCTURE.

Matanuska Valley is believed to be a sunken fault block and is bounded by two major faults parallel to the valley walls. The coal-bearing rocks are thus confined to the valley, and the surrounding mountains are made up of older formations from which the Tertiary rocks have been removed by erosion. Faulting has been so general throughout the region as to affect nearly every workable coal bed that has been opened. This faulted condition is a serious obstacle to economical mining and must always be taken into account in opening up a new tract.

At Moose Creek the faulting has temporarily hindered the development of the mine. In most places on Eska Creek the faulted parts have so far been found easily, but the coal-bearing area is known to be bounded on the north by a fault zone beyond which it is not considered feasible to prospect on account of the broken condition of the ground, and to be limited on the east also by a fault that brings it against the barren Cretaceous rocks. At Chickaloon the coal-bearing area is broken by one main fault and a series of parallel faults that limit the principal coal bed to a known length of 600 feet.

The coal beds are also closely and irregularly folded, a structural feature that will add considerably to the cost of mining the coal. The main structural features are shown in Martin's report,[1] and details of both structure and stratigraphy that were worked out in 1918 are given in the following descriptions of mines and prospects.

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, pl. 2, 1912.

COAL.

AREAL DISTRIBUTION.

The areal extent of the coal lands is described by Martin[1] as follows:

The coal of the Matanuska Valley occurs in several isolated fields. * * * The Chickaloon field is situated mostly in the lower part of the valley of Chickaloon River but extends west as far as Kings River, south across the Matanuska into the valley of Coal Creek, and possibly east beyond the Chickaloon Valley. The Eska-Moose field, which is second in area and importance, extends from the valley of Eska Creek west as far as Moose Creek and possibly into the gravel-covered area beyond it. The Young Creek field is intermediate in geographic position between the Chickaloon and Eska-Moose fields, being situated in the upper part of the valley of Young (Little Kings) Creek. * * *

The areas of the "coal-bearing rocks" can not be assumed to be underlain wholly by beds of coal of workable character and thickness. Moreover, parts of these areas may have no coal under them. The lack of knowledge as to the exact stratigraphic position of the coal beds, the uncertainty as to what stratigraphic parts of the "coal-bearing rocks" are represented by the several surface outcrops, and the concealment of the rocks by gravels over broad areas make the precise areal distribution of the coal a problem which can be solved only by drilling or other underground exploration.

The subjoined tables prepared by Martin indicate the probable and possible areas of supposed "coal-bearing" rocks in the lower Matanuska Valley as revised in 1913. These tables show the areas of probable coal occupied by the so-called "coal-bearing" rocks and overlying beds, and the possible coal areas which may be underlain by coal but in which other formations may be present.

Areas of supposed coal-bearing rocks in the lower Matanuska Valley, in square miles.

Valleys of Chickaloon and Kings rivers	41.1
South of Matanuska River in vicinity of Kings Mountain and Coal Creek	6.4
Valley of Young Creek	3.0
Valleys of Moose and Eska creeks	19.8
	70.3

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, 1912. Martin, G. C., and Mertie, J. B., jr., Mineral resources of the upper Matanuska and Nelchina valleys, Alaska: U. S. Geol. Survey Bull. 592, 1913.

Areas of possible extensions of the supposed coal-bearing rocks in the lower Matanuska Valley, in square miles.

Lower parts of valleys of Kings River and Granite Creek	9.1
Valleys of Moose and Eska creeks	15.8
	24.9

CHARACTER OF THE COAL.

PHYSICAL CHARACTER.

The coal of the lower Matanuska Valley where mining has been carried on ranges in character from high-rank to low-rank bituminous. By high-rank coal is meant one that is relatively high in fixed carbon and low in volatile matter and moisture. The term high grade is used to designate a coal of any rank which is relatively free from impurities. The areal distribution of the coal of different ranks in the Matanuska Valley bears a close relation to the structure and deformation of the inclosing sediments. The low-rank bituminous coal of the Eska-Moose tract occurs in rocks that lie in a gently folded syncline, and the rocks which carry the bituminous coal of higher rank in the Chickaloon tract in the upper part of the valley are closely folded and in places tilted beyond the vertical. This dependence of the character of the coal upon the structure is further shown in the area west of Matanuska Valley. The coal found between Moose Creek and Cook Inlet all occurs in flat-lying rocks and, although evidently of about the same age as the coal of Matanuska Valley, is lignitic. These facts appear to show that the coal is of progressively higher rank toward the east, where the folding has been more intense—at least, as far as Chickaloon.

CHEMICAL ANALYSES.

Analyses of the Matanuska coals have been published from time to time in the bulletins of the Geological Survey.[1] The following analyses of the beds now being mined at Eska were made at the time the property was under examination for the Alaskan Engineering Commission:[2]

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska; U. S. Geol. Survey Bull. 500, pp. 90–92, 1912.

[2] Smith, S. S., Alaskan Engineering Commission, Mining Dept., Report for year ending Dec. 31, 1917.

Analyses and tests of Eska Creek coals.

Bed.	Air-drying loss.	Form of analysis.	Proximate analysis.				Ultimate analysis.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
Eska bed	2.1	Air dried	2.87	38.86	40.41	17.86	0.38	5.28	63.36	1.46	11.66	6,327	11,389
		As received	4.94	38.03	39.55	17.48	.37	5.41	62.01	1.43	13.30	6,192	11,146
		Moisture free		40.01	41.60	18.39	.39	5.11	65.23	1.50	9.38	6,514	11,725
		Moisture and ash free		49.92	50.98		.48	6.26	79.93	1.84	11.49	7,982	14,368
Emery bed	2.2	Air dried	3.33	40.00	46.75	9.92	.34	5.53	70.05	1.57	12.59	7,025	12,645
		As received	5.43	39.13	45.74	9.70	.33	5.65	68.53	1.54	14.25	6,873	12,371
		Moisture free		41.38	48.36	10.26	.35	5.34	72.46	1.63	9.96	7,268	13,082
		Moisture and ash free		46.11	53.89		.39	5.95	80.74	1.82	11.10	8,099	14,578
Maitland bed	4.0	Air dried	3.12	36.88	38.91	21.09	.41					6,017	10,831
		As received	6.99	35.41	37.35	20.25	.39					5,777	10,399
		Moisture free		38.07	40.16	21.77	.42					6,211	11,180
		Moisture and ash free		48.66	51.34		.54					7,940	14,292
Maitland bed (lower bench)	1.9	Air dried	3.23	42.82	46.58	7.37	.65	5.52	71.69	1.64	12.33	7,223	13,001
		As received	5.06	42.01	45.70	7.23	.44	5.63	70.34	1.61	14.75	7,086	12,755
		Moisture free		44.25	48.13	7.62	.46	5.34	74.09	1.70	10.79	7,464	13,435
		Moisture and ash free		47.90	52.10		.50	5.78	80.20	1.84	11.68	8,080	14,544
Kelly bed (lower bench)	2.5	Air dried	2.69	43.09	45.21	9.01	.41	5.52	70.74	1.57	12.75	7,037	12,667
		As received	5.13	42.01	44.08	8.78	.40	5.66	68.96	1.53	14.67	6,860	12,348
		Moisture free		44.28	46.47	9.25	.42	5.36	72.69	1.61	10.67	7,231	13,016
		Moisture and ash free		48.79	51.21		.46	5.91	80.10	1.77	11.76	7,622	13,720
Kelly bed (upper bench)	2.2	Air dried	2.74	42.56	47.61	7.09	.55	5.81	72.77	1.68	12.10	7,320	13,176
		As received	4.84	41.64	46.58	6.94	.54	5.92	71.20	1.64	13.76	7,162	12,892
		Moisture free		43.75	48.95	7.29	.57	5.65	74.82	1.72	9.95	7,527	13,549
		Moisture and ash free		47.20	52.80		.61	6.09	80.70	1.86	10.74	8,119	14,614
David bed	2.0	Air dried	3.60	42.38	48.40	5.62	.53	6.84	72.34	1.66	13.01	7,226	13,295
		As received	4.90	41.55	48.04	5.51	.52	5.95	71.90	1.63	14.49	7,741	13,994
		Moisture free		43.69	50.52	5.79	.35	5.59	75.90	1.71	10.66	7,614	13,705
		Moisture and ash free		46.38	53.62		.85	5.94	80.25	1.82	11.11	8,582	14,548

STEAMING QUALITIES.

In 1914, 586 tons of coal from the Chickaloon mine was submitted to an exhaustive test by the Navy Department. This test, made on the U. S. S. *Maryland*, included use of coal as follows:

1. An uninterrupted period of 7 days in port.
2. A test at sea for 24 hours with not more than three-fourths boiler power, and at a speed of 15 knots.
3. A test at sea for 4 hours under full boiler power at speed of 20 knots.
4. A test at sea of 40 hours at speed of 10 knots.

The Navy Department also submitted the coal to laboratory tests and to full analyses. As a result of these tests the board appointed to pass on the coal reported[1] that "the sample of Matanuska coal tested is suitable in every respect for use in the naval service."

COKING AND BY-PRODUCT QUALITIES.

A field test of the coking qualities of the Chickaloon coal was made in 1905 by Martin[2] who says:

The resulting coke was hard and firm and had a good ring and a good texture. The test indicated that by proper treatment a coke of satisfactory grade can be produced. No further tests have been made by members of the Geological Survey. The analyses indicate, however, that the high-grade bituminous coal on Chickaloon and Kings rivers and on Coal Creek is probably, at least in part, coking coal, and that the coal in the west end of the district, on Moose, Eska, and Young creeks, is low-grade bituminous and is probably all noncoking.

In 1918 a coking test on 6 tons of washed Chickaloon coal was made by the Bureau of Mines at the Wilkeson coking plant of the Wilkeson Coal & Coke Co., under the direction of George W. Evans. The analyses of the coal used for the test and of the resulting coke given below are taken from an informal report to the Alaskan Engineering Commission.

Analyses of Chickaloon coal used in coking test at Wilkeson coking plant and of resulting coke.

	Moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.
Coal	1.0	22.52	65.87	10.61	0.49
Coke	.55	.70	85.45	13.30	.57

The coke is reported by Mr. Evans to be of good appearance, and a foundry test made on about 3 tons of it by the Puget Sound Iron & Steel Works, of Tacoma, Wash., was satisfactory and indicates its suitability for foundry purposes.

[1] Sixty-fourth Cong., 1st sess., S. Doc. 26, p. 9, 1915.

[2] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, p. 92, 1912.

The following report was made by F. W. Speer, jr., on a sample of coal taken from bed 8 at Chickaloon, submitted by the Bureau of Mines to the laboratory of H. Koppers Co., Mellon Institute, Pittsburgh, Pa.:

Proximate analysis:	
Volatile matter	21.14
Fixed carbon	72.37
Ash	6.49
Sulphur	.57
Distillation:	
Water	3.077
Carbon dioxide	.787
Hydrogen sulphide	.088
Composition of gas (calculated to oxygen-free basis):	
C_nH_m	2.6
CO	4.9
H	60.4
CH_4	29.8
N_2	2.3
Ratio: $\frac{\text{Fixed } NH_3}{\text{Total } NH_3}$	.033
Specify gravity of gas	.30
British thermal units in gas per pound of coal	2,979
Practical yields per net ton:	
Tar gallons	4.4
Sulphate pounds	20
Gas at 15° C., 760 mm. Hg cubic feet	10,850
Coke per cent of coal	81.3
Light oil (estimated to contain 55 per cent benzol and 12 per cent toluol) gallons	1.9

Remarks: This is a coking coal similar in quality to Pocahontas. It would probably produce a similar coke, but the exact character of the coke can only be determined by making an oven test. Such coal usually requires mixing with some high-volatile coal in order to avoid trouble due to expanding and sticking.

The possibility of the utilization of the Matanuska coals for their by-products should be investigated when sufficient coal reserves are developed. A ton of bituminous coal will produce in round numbers 10,000 cubic feet of gas, three-quarters of a ton of smokeless fuel, 20 pounds or more of ammonium sulphate, 2 gallons of light oil, and from 4 to 9 gallons of tar. The carbon residue when briquetted furnishes a fuel approaching hard coal in value, and both it and the gas might be used for industrial and domestic purposes. Recoverable by-products that would find a local market are tar for road dressing, ammonium sulphate for fertilizer, and benzol for motor oil. Other by-products are toluol, essential in the manufacture of high explosives, dyes, and chemicals.

MINING.

DEVELOPMENT.

The coal-land leasing act passed by Congress in 1914 provided for the survey of lands in Alaska known to be valuable for their deposits of coal and the division of such coal lands not reserved for naval and other governmental uses into leasing blocks or tracts. The Matanuska coal field, which was designated in the act as one of the fields to which preference was to be given, was subdivided in 1915 into 19 leasing units and Government reservations, and on May 8, 1916, the leasing units were offered for leasing by the Secretary of the Interior.[1]

The same year some coal was mined on Moose Creek, at the Doherty mine, which was operated on a 10-acre permit, by the Doherty Coal Co.

The lease on units 2 and 3 on Moose Creek was granted early in 1917, and work on this property, known locally as the Baxter mine, was started in October. From December, 1917, to April, 1918, coal was mined and sledded to Moose Creek for shipment to Anchorage, where it was taken in part by individuals and in part by the Alaskan Engineering Commission.

The Eska Creek Coal Co. took over the lease originally obtained by William Martin for unit 7 on Eska Creek and began mining coal in January, 1917. The coal was sledded 3 miles to the Matanuska branch of the railroad at Sutton until the Eska spur was built. The production at first was only about 35 tons a day, but the exposures indicated extensive coal resources, and upon the promise of a large tonnage the spur line was built to the mines. The mining operation, however, soon ran into faulted ground, and production stopped.

In February of the same year a lease on units 10 and 11, between Chickaloon and Kings rivers, was granted to Lars Netland for the Chickaloon Coal Co., which began active developments on the property.

The outlook for an adequate supply of coal for the railroad was not very bright. Operations at Eska were hampered by faulted ground and by lack of time and capital for exploration and development work. The Baxter leasehold on Moose Creek was still in the prospect stage, and the coal deposits were 4½ miles from the railroad. The coal produced at the Doherty mine was of poor quality and insufficient in quantity to meet the needs of the commission. The available coal was about 100 tons a day, only about half the amount necessary to supply the needs of the commission.

[1] Regulations governing coal-land leases in the territory of Alaska, Interior Dept., 1916.

The commission, having realized the risk of relying upon private interests to supply an adequate supply of coal for the needs of the railroad, had requested that unit 12 be set aside for its use. No coal from this unit or from the lease of the California Coal Co. on units 10 and 11 could be available, however, until the completion of the Matanuska branch of the railroad to Chickaloon.

In the spring of 1917 Sumner S. Smith and George W. Evans, of the Bureau of Mines, made an investigation of the conditions of mining in the Matanuska field, as regards safety precautions observed underground and methods of mining and treating the coal, and reported to the Alaskan Engineering Commission[1] the conditions as outlined above, and recommended that the Alaskan Engineering Commission either offer the Eska Creek Coal Co. a contract that would enable it to install the proper equipment to explore the faulted ground and other known beds or purchase or lease unit 7 from the Eska Creek Coal Co. and mine coal for its own use until explorations by private operators in other parts of the fields had developed mines large enough to supply the necessary amount of coal.

The Alaskan Engineering Commission finally purchased the property and took over the lease on June 18, 1917, the same day that unit 12 on Chickaloon River was set aside by Executive order for the use of the commission. Sumner S. Smith was placed in charge of the Government-controlled properties at Eska and Chickaloon and began the active development of the mines. In 1918 the Eska mine produced over 150 tons a day throughout the year. At Chickaloon 4,000 tons of coal was mined incidental to prospecting and development operations. Recent developments are recorded in the descriptions of the mines and prospects.

PRODUCTION.

The production of the Matanuska coal fields for 1918 was 63,091.6 tons. This coal came from three properties—the Baxter mine, on Moose Creek, which operated for a part of the year, and the Government-operated mines at Eska and Chickaloon. The greater part of the output was from Eska, where an average of over 150 tons a day was maintained throughout the year. This does not represent a capacity production, for the Alaskan Engineering Commission has been mining coal primarily for its own use on the railroad and has mined only enough to supply its needs and keep a reasonable surplus on hand. The output of 4,180 tons from Chickaloon was obtained from development operations. The lack of transportation facilities

[1] Smith, S. S., Alaskan Engineering Commission, Mining Dept., Report for year ending Dec. 31, 1917.

at the Baxter mine obviously limits the productive mining season to the winter, when the coal can be sledded to the railroad.

There appears to be little prospect of an increased production in 1919 except through Government activities. Private interests have not yet successfully developed a mine. The Chickaloon Coal Co. is actively prospecting its ground, but so far has not met with enough success to give much hope of making a production during the coming year. The Baxter mine will require transportation facilities and considerable development to bring it to the productive stage, beyond the mining out of a block of coal in the fault block. This mine is now (1918) idle, and no development work has been done for some months.

Chickaloon is still in the prospect stage.[1] The detailed geologic work done in 1918 indicates that the beds are very lenticular and vary greatly in size and character from place to place, and that the main bed, on which the principal hopes of developing the mine are based, either feathers out within a distance of 1,000 feet or less into a number of small beds of inferior coal or is faulted to such an extent that the bed has not been located in the underground workings. At Eska there is coal enough in sight to last several years at the present rate of mining, and the production could be considerably increased if necessary.

Coal produced in the Matanuska field, 1916–1918, in short tons.

1916	8, 395
1917	45, 370
1918	63, 092
	116, 857

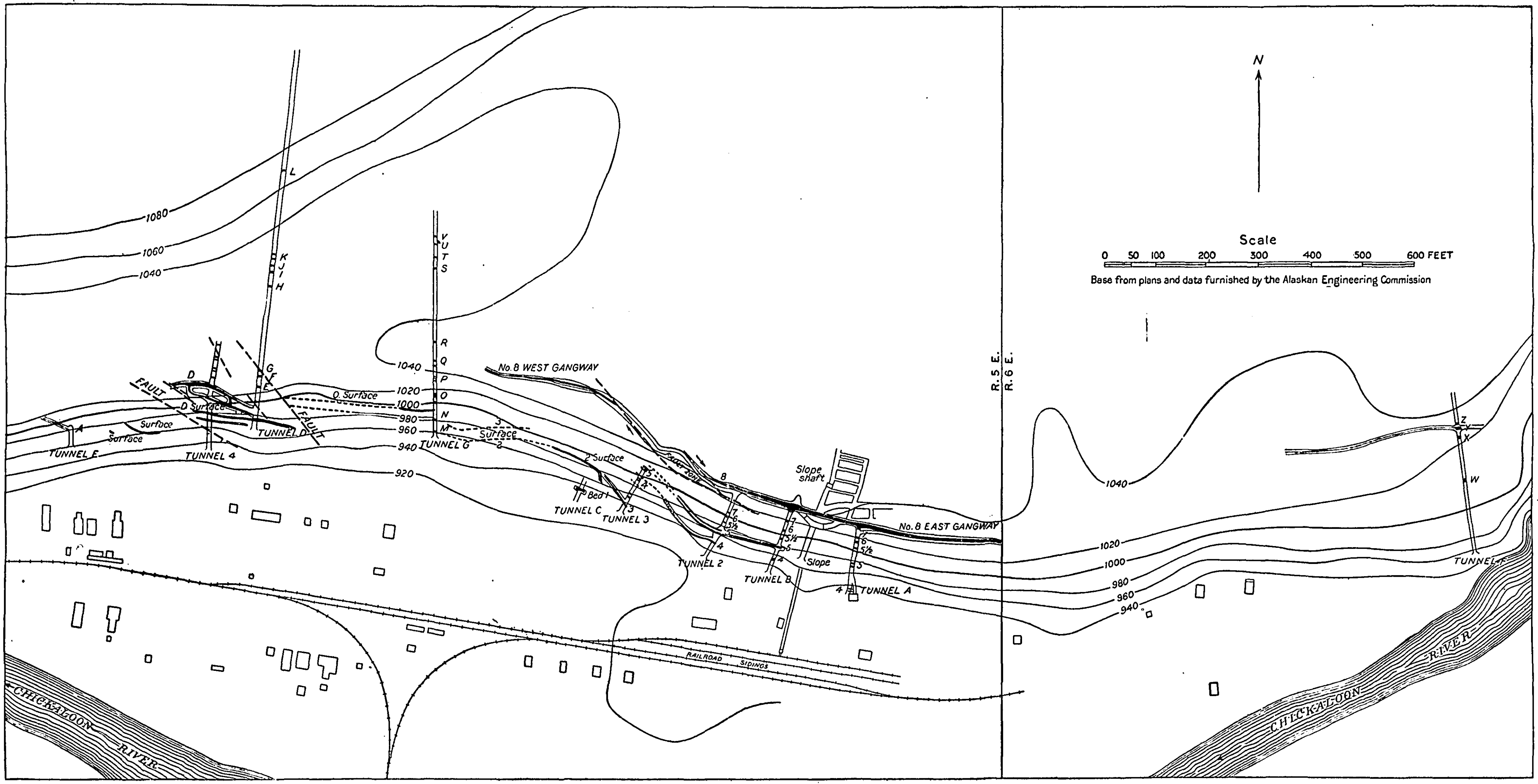
CHICKALOON MINE.

LOCATION AND DEVELOPMENT.

The Chickaloon coal mine is on leasing unit 12, at the terminus of the Matanuska branch of the railroad, 75 miles from Anchorage.

The coal crops out on the north bank of Chickaloon River, which at this place has cut through the gravel covering and underlying coal measures and exposed the coal beds in a bluff that rises 100 feet from the alluvial flat of the river to a terrace covered with glacial gravels.

[1] Since the above was written mining developments have been continued at both the Eska and Chickaloon mines. At Eska about 150,000 tons of coal has been definitely blocked out, and the coal beds now being mined have been traced at the surface by open cuts for about a mile, indicating, according to S. S. Smith, a coal reserve of about 1,000,000 tons. At Chickaloon a slope has been sunk for 600 feet, and over 100,000 tons of high-grade blacksmith coal has been blocked out.—A. H. Brooks.



SKETCH MAP OF WORKINGS OF THE CHICKALOON COAL MINE, SHOWING PRINCIPAL FAULTS AND LOCATION OF COAL BEDS.

The mine is being developed by a number of crosscut tunnels and connecting drifts driven along the best coal beds. The coal measures exposed on this bluff and by the underground workings stand nearly vertical and in places are overturned, so this method of driving tunnels perpendicular to the strike gives a crosscut approaching the stratigraphic section and appears to be an economical way of exploring the measures underground to determine the structure and stratigraphy of the rocks and the continuity of the coal beds, for the area is largely covered with glacial gravel and even the outcrops on the banks of streams are partly concealed by talus. The nine tunnels (Pl. IV) in order of sequence from east to west are numbered F, A, B, 2, 3, C, G, D, 4, and E.

In these workings 10 or more coal beds have been cut, and the best ones have been explored by drifts along their strike. The principal work has been done on what is known as bed 8, a 17-foot bed of coal which has been opened by a gangway and counter along its strike for 600 feet and explored by a shaft to a depth of 583 feet. The present scheme of development is simply a continuation of the prospecting work started by the private operators who endeavored to open up the coal beds and is designed to prospect the tract and to determine the character and extent of the workable coal beds.

When the Chickaloon mine was taken over for operation by the Alaskan Engineering Commission tunnels A, B, 2, 3, D, 4, and E had been started by the former operators. Tunnels A and B had been driven to bed 8 and a drift extended along it for 300 feet. Bed 5 also was opened by a drift from tunnel B to tunnel 2, and drifts extended westward from tunnel B along beds 4 and 5. Tunnels 4 and D had each been driven about 100 feet, and 250 feet of connected workings extended from them on bed D.

The first work of the commission was to sink a working shaft on bed 8 between tunnels A and B, to continue tunnel 2 to bed 8, to extend the gangway along bed 8 both east and west, to extend tunnels 4 and D 90 and 250 feet, respectively, and to drive tunnel F 170 feet. All this work was done in 1917.

During 1918 the shaft was continued to a depth of 583 feet, the east and west gangways and counters on bed 8 were extended to a total length of 1,080 feet, tunnel D was driven to a length of 780 feet, the drifts on bed D were extended from tunnel H, and tunnel G was driven 400 feet. This work has all been in the nature of prospecting. In driving westward on bed 8 a prominent fault was encountered, which displaced the bed toward the northwest, and tunnels D and G were driven to prospect the fault block west of the fault, and if possible to find the faulted part of bed 8.

Tunnel D crosses a number of coal beds, but as none of these resembled the coal in the eastern tunnels, it was continued until a thick barren zone was entered and the work was stopped temporarily. Tunnel G was then driven, and a number of coal beds were cut. None of these can, with certainty, be determined as bed 8, but some suggested correlations are presented in this report.

Tunnel F was driven 300 feet, and drifts extended east and west, respectively, 45 and 340 feet along bed Y, the possible equivalent of bed 8.

The mine is equipped with bunk houses, hospital, dining room, dry house, power plant, fan houses, blacksmith shop, office buildings, storehouses, and barns. There are also a number of private buildings, including road houses, stores, barber shop, pool hall, and laundry. The resident engineer in charge maintained temporary headquarters at Chickaloon during the summer of 1918 but moved in November to Eska.

GEOLOGY.

STRATIGRAPHY.

The stratigraphic section exposed in each tunnel of the Chickaloon mine is shown in Plate V. The correlation of the coal-bearing beds, however, is in doubt. The outcrops are too scattered and gravel-covered to be followed on the surface for any distance, and the coal beds have no distinct markers or other characteristics that serve to identify them, and they vary so greatly in size of bed and character of coal that it is not easy to recognize a bed from place to place solely on its physical appearance. The inclosing rock formations also change along the strike in thickness and character and are lacking in any distinct persistent markers that might serve to correlate one section with another. The sections exposed by tunnels A, B, 2, and 3, although showing considerable variation from place to place, are similar enough to permit correlating the coal beds, at least, without much doubt. The same may be said of the sections exposed in tunnels G, D, and 4, but between the sections exposed in these two groups of workings there is much less similarity. Bed 8, for instance, in tunnels A, B, and 2 is about 17 feet thick, but there is nothing to correspond to it in size or general appearance to the west. This at first led to the belief that bed 8 had been carried by the fault beyond the faces of tunnels G and D, and that the section exposed in these tunnels is stratigraphically below the rocks cut in tunnels A, B, and 2.

This does not seem probable, however, for, as is brought out later, there is no indication of faulting of such magnitude, and besides the beds cut by tunnels A, B, and 2 appear to be the same as a part of those in tunnels G and D. This correlation was established by digging a series of pits, by means of which it was possible to trace and project beds 2 and 3 across the partly concealed interval between the bluff above tunnel C and the mouth of tunnel G. Inasmuch as the stratigraphic relation of these two sections is important on account of its bearing on the position and character of bed 8—as indicating whether that bed occurs in tunnels G and D or is to be looked for elsewhere—the following correlations are suggested as probable, though not positively proved. Even with beds 2 and 3 identified near the mouth of tunnel G and used as a starting point it is not possible to correlate the overlying beds with certainty.

The most plausible correlation is made by assuming that bed 8 has split up into a number of benches and is represented by beds H, I, and J in tunnel G and S, T, and U in tunnel D. The underlying beds, 7 to 2, are correlated with those exposed in tunnels G, D, and 4 as brought out in the following discussion.

An alternative correlation, which was at first made, is to consider the upper part of bed O in tunnel G as the two benches of bed 5 and to correlate beds E and P with 5½, 6, and 7; beds F and Q with 8; and beds G and R with 9. This correlation seems much less probable than the other, as it would indicate a thinning out toward the west of the rocks between the coal beds, a supposition which is contrary to the observed facts.

If the correlations that follow are correct, the known coal beds exposed on Chickaloon River occur in three groups of beds separated by barren intervals of shale and sandstone forming a series of rocks 600 to 750 feet thick, which strike about east. The normal dip is toward the north, but in places the beds are folded beyond the vertical and actually dip toward the south.

Bed 1 is exposed in tunnel C but does not show in any of the workings to the east and crops out for only a short distance on the surface. It is possible that this is the same as bed A in tunnel E, which is composed of 11 feet of carbonaceous shale and coal. Bed 1 in tunnel C contains about 3 feet of coal and shows little resemblance to bed A, but this correlation is suggested by the relation of each to overlying beds.

Bed 2 crops out above tunnel C but is not cut in any of the tunnels to the east. It contains about 3 feet of bony coal underlain by 2 feet of carbonaceous shale and bone. Bed 2 was traced westward from the bluff above tunnel C and is believed to have been identified as bed M near the mouth of tunnel G. Beds B and M also are believed to be the same bed.

Bed 3 crops out on the bluff above tunnel C and is cut by tunnel 3 and opened by a drift for 60 feet. It is also believed to be the same as bed N in tunnel G and as bed C, which is cut in tunnel 4 and which crops out on the hillside between tunnels 4 and E. On the surface above tunnel 3 it is 3 feet thick, and occurs in two benches of clean, bright coal separated by 1 foot of bony coal with silicified tree trunks. In tunnel 3 bed 3 is 3½ feet thick. The upper half of the bed is good, clean coal, but the lower part contains much bone and dirt and in places silicified tree trunks. Toward the west the bed improves, and at the face of a 60-foot drift driven from tunnel 3 it has the following section:

Section of bed 3 at west end of drift from tunnel 3.

	Ft.	in.
Shale roof.		
Carbonaceous shale		5
Bright coal	2	6
Hard shale		1
Coal		6
Bone		2
Massive shale floor.		

In tunnel G, bed N is composed of 2 feet of bony coal. Bed C in tunnel 4 has about 18 inches of bony coal, and where it crops out west of the tunnel it is from 1½ to 2 feet thick and contains the characteristic silicified tree trunks.

Bed 4 is cut by tunnels A, B, 2, and 3 and crops out on the surface above them. In tunnel 3 it has 2 feet 4 inches of coal, overlain by 3½ feet of bone and shale, but is very lenticular and decreases toward the east. In tunnel 2 it contains about 2 feet of coal and bone, and in tunnels B and A it contains only lenses of coal ad carbonaceous shale.

Bed 4 is correlated with bed O in tunnel G and bed D in tunnels D and 4. If this correlation is correct, it increases in value toward the east at least as far as tunnel 4. Farther west bed D evidently pinches, and in the workings of the Chickaloon Coal Co. merges into carbonaceous shale. In tunnel G, strata which are correlated with bed 4 contain 19 feet of coal and shale. If this correlation is correct, bed 4, besides increasing in thickness, is also splitting up into benches toward the west. Bed O crops out on the surface westward from tunnel G nearly to tunnel D, where it appears to have been faulted from bed D, with which it is believed to have been at one time continuous.

Much uncertainty exists regarding the identity of bed D in tunnel D and bed O in tunnel G. The position of the outcrops of these two beds would indicate that they are not the same and that bed D is much lower stratigraphically, unless a fault separates these two beds. The trace of a fault occurs on the surface between the outcrops of the beds, along which the movement may have taken place that brought them to their present position. The faulting, however, may have been in the opposite direction, and bed D may occur below any beds cut by tunnel G.

Bed D is opened by tunnels 4 and D and by connecting workings and crops out on the surface for 200 feet. It is from 5 to 8 feet wide and swells and narrows within a short distance. It is also badly crushed and broken by many faults. None of these are believed to be extensive, but they have offset the bed in a number of places and will greatly increase the cost of mining it.

Bed 5 has been opened by tunnels A, B, 2, and 3, and wherever exposed shows two benches except in tunnel 3, which evidently is not extended far enough to cut the upper part. In tunnel 2 bed 5 has the following width:

Section of coal bed 5 in tunnel 2.

		Ft.	in.
Coal (bed upper 5)	Bone and coal	1	6
	Coal	2	6
	Bone and coal	2	
Carbonaceous shale and bone		3	
Coal (bed lower 5)	Coal with some bone	3	10
	Carbonaceous shale and bone	1	2

Bed 5 decreases in size and becomes poorer in quality toward the east. In tunnel B the upper and lower benches are respectively 5½ and 3 feet thick and are separated by 1 foot of shale and bone. In tunnel A it has merged into two beds of carbonaceous shale with a parting of nodular shale. In tunnel 3 bed 5 is composed of 5 feet of dirty coal. This is evidently the lower bench.

Bed 5 is correlated with bed P of tunnel 4 and E of tunnel D. Bed P occurs in three benches aggregating 4¾ feet of coal with a thick shale parting. Bed E is 2 feet 8 inches thick but contains large niggerheads.

Bed 5½ is exposed in tunnels A, B, and 2. In tunnel B it contains 3½ feet of bony coal, but in tunnels A and 2 it is less than 3 feet thick and is more bony. Bed 5½ is believed to be the same bed as Q and F.

Bed 6 is also exposed in tunnels A, B, and 2. In tunnel B it has the following thickness:

Section of bed in tunnel B.

	Ft.	in.
Coal		6
Shale		6
Coal	1	6

In tunnel A it contains 3 feet of coal with some bone. In tunnel 2 it is 2½ feet thick and contains some impurities. It is correlated with beds R and G and also with bed W in tunnel F and the bluff east of it.

Bed 7 as exposed in tunnel 2 is about 1 foot thick. In tunnel B it has merged into 6½ feet of carbonaceous shale with streaks of coal, and in tunnel A is a narrow bed of impure coal. It is possibly bed X in tunnel F and on the bluff exposure near by. Bed 7 is not correlated with any coal bed in tunnels D or G. It may have pinched out or may have merged into one of the shale beds between beds R and S and between G and H.

Bed 8 is exposed near the face of tunnels A, B, and 2 and has been opened by a gangway and counter for 600 feet and explored by a shaft to a depth of 583 feet. In all these exposures it maintains a width of about 17 feet between walls. The following section is taken from a published report:[1]

Section of bed 8 in tunnel B.

	Ft.	in.
Coal with shale and bony beds.		
Coal	1	6
Shale		3
Coal	4	3
Shale		2
Coal	1	1
Irregular shale mass		5
Coal		11
Shale		8
Coal		11
Shale		4
Coal	1	6
Shale with many coaly beds		11
Coal	4	2
Shale with coal and bone partings.		

Bed 8 is faulted in both the east and west gangways, and the object of much of the prospecting has been to find the faulted part of the bed. So far this has not been done with certainty, but correlations are suggested in harmony with those already made for the lower beds. Toward the west bed 8 is believed to have split up into three branches and in tunnel G to be represented by beds S, T, and U and in tunnel D by beds H, I, and J. Beds S, T, and U contain about 14 feet of coal, nearly as much as the actual coal in bed 8 but broken up into smaller beds and mixed with much shale. Beds H, I, and J in tunnel 4 contain considerably less coal, and the beds in tunnel 3 of the Chickaloon Coal Co., with which these beds are correlated, are smaller yet. If this correlation is correct, therefore, it appears that bed 8 breaks up into benches and thins out toward the west. The largest of the supposed equivalents of beds H, I, J, and K, in Chickaloon Coal Co. tunnel contains 2½ feet of good coal, but the other beds are from 1½ to 2 feet thick and are separated by an aggregate of over

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, p. 79, 1912.

60 feet of shale. This correlation of bed 8 with beds H, I, and J implies a progressive thickening of the stratigraphic section toward the west and is in keeping with conditions in tunnels A, B, and 2.

Bed 8 is possibly also the same as bed Y in tunnel F and on the bluff near by. If so, bed 8 has thinned out greatly between the face of the No. 8 east gangway and tunnel F. Where first cut in tunnel F it has a thickness of 3 feet. Along the drift to the west it pinches and widens but maintains an average width of 2½ feet or more. The correlation of beds 8 and Y is suggested with considerable doubt. Beds X and Y may be the equivalent of bed 8, or the entire section exposed in tunnel F may be at a horizon entirely different from that of the beds exposed in any of the other workings.

Bed Z in tunnel F, bed 9 in tunnels A, B, and 2, bed V in tunnel

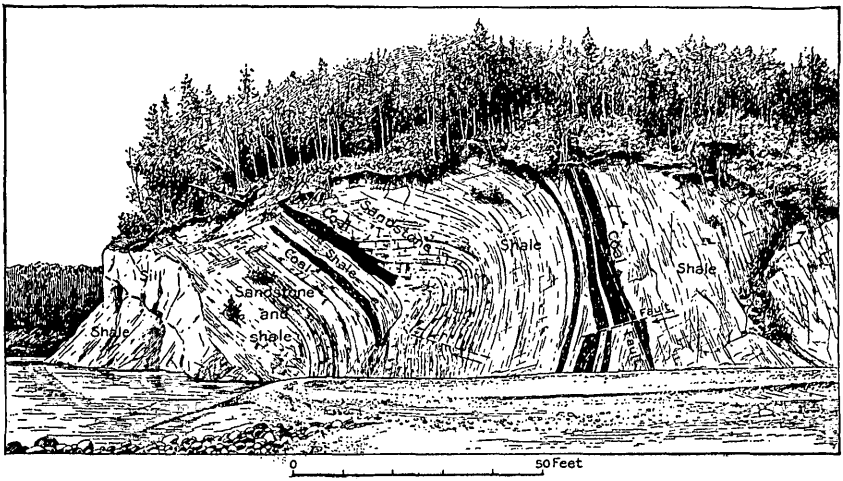


FIGURE 2.—Sketch of bluff on Chickaloon River above Chickaloon mine.

G, and bed K in tunnel D are correlated, a conclusion that follows from the foregoing deductions.

STRUCTURE.

The coal-bearing rocks of Chickaloon lie in a monoclinal block broken by one main fault and a number of minor parallel ones. In the western part of the tract the beds dip from 25° to 50°, but toward the east the dips become steeper. The normal dip is toward the north, but in the southeastern part of the tract the beds are folded beyond the vertical, at one place more than 180° from their original position. The strike ranges from N. 70° W. to N. 80° E.

The folding is marked by very sharp flexures, which in places pass into actual breaks that have faulted the coal beds. (See fig. 2.)

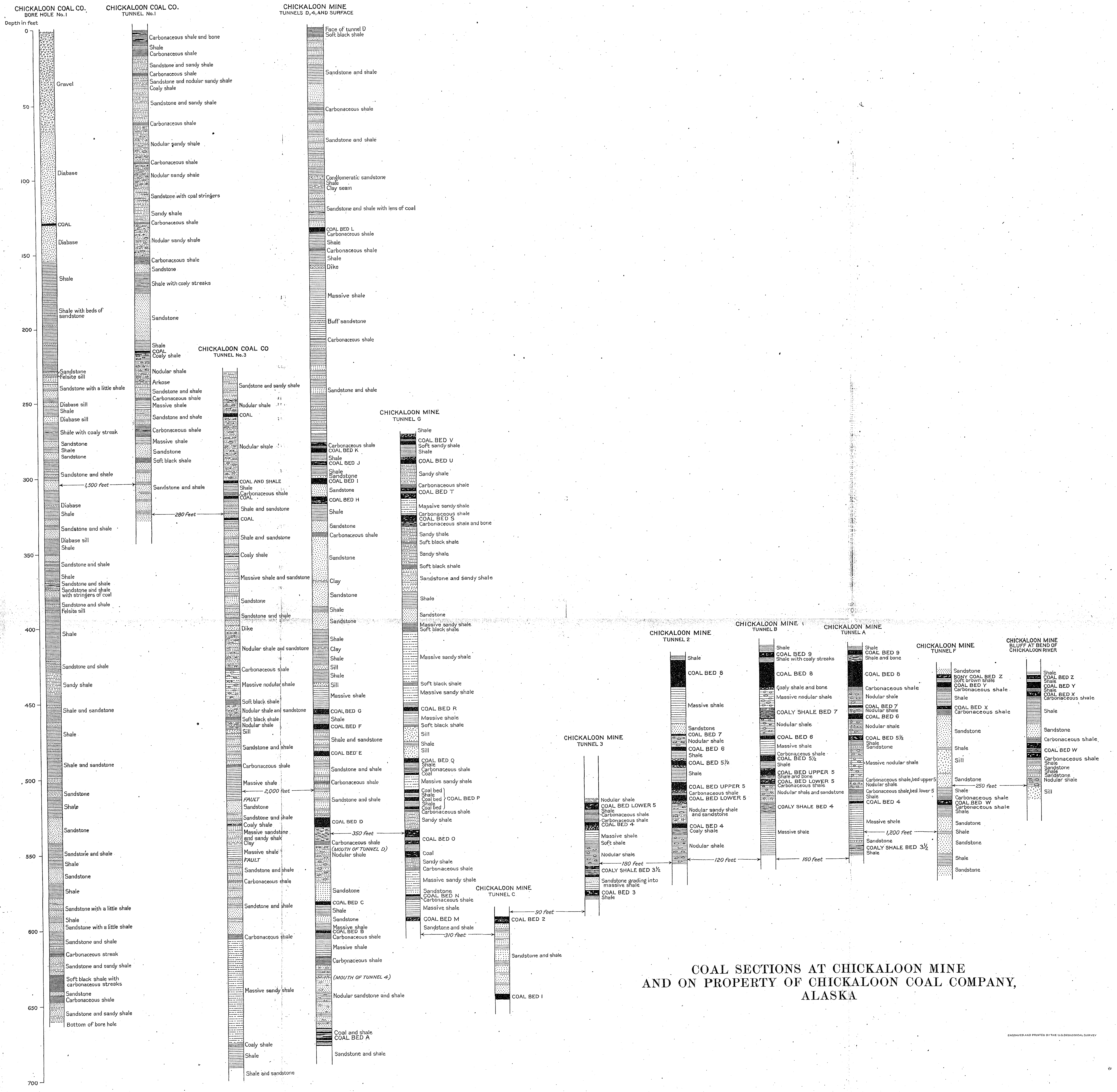
One main fault crosses the tract with a general northwesterly strike and nearly vertical dip. The movement appears to have been nearly parallel to the strike of the fault, so that the heave or horizontal component of the movement nearly represents the actual displacement. The faulting did not occur along a single plane but was distributed over a zone from 50 to 70 feet wide. The relative movement of the northeast block toward the southeast is readily seen by the bending of the coal beds as shown on Plate IV.

The amount of displacement along the main fault is not known, for the faulted part of bed 8 southwest of the fault has not been positively identified. If the conclusions drawn are correct, the horizontal displacement along the fault plane is about 650 feet, and if bed 8 is exposed in any of the tunnels southwest of the fault the displacement must have been at least 350 feet. The fault near the face of tunnel G is believed to be this main fault, which evidently passes north of the face of tunnel D. This fault is best seen in the No. 8 west gangway, west of the face of tunnel 2, where bed 8 is abruptly cut off. For some distance northwest of this point the workings follow the fault plane along which large blocks of bed 8 have been dragged.

The continuation of this fault southeast of the point where it cuts bed 8 is not evident. Tunnel 3 has not been driven far enough to intersect it, and it appears to cross tunnel 2 about midway between the position of beds 7 and 8. Here the movement appears to have been about parallel to the strike of the beds. In the workings east of tunnel 2 no evidence of the fault was seen, and it is probable that the stresses which caused the rupture of bed 8 were taken up by bending of the beds and movement along the bedding planes and caused no break across the coal beds. Another region in which there appears to be considerable faulting is near the mouth of tunnels D and 4, both in the underground workings and on the surface, but none of the faults are known to be extensive.

If the correlations made between beds exposed in tunnel G and in tunnels D and 4 are correct, there appears to be faulting at this place, in which the horizontal displacement was in the opposite direction to that caused by the main fault.

East of the main fault the beds are greatly compressed, stand at high angles, and are partly overturned. West of the main fault except where locally disturbed by faulting the structure is more regular; the beds are nowhere overturned and dip at much lower angles. These favorable structural conditions, however, are more than offset by the unfavorable condition of the coal beds, which toward the west break up into smaller beds with shale partings or pinch out entirely.



COAL SECTIONS AT CHICKALOON MINE AND ON PROPERTY OF CHICKALOON COAL COMPANY, ALASKA

CHICKALOON COAL CO.'S PROPERTY.

LOCATION AND DEVELOPMENT.

The Chickaloon Coal Co., of San Francisco, holds a lease on units 10 and 11 on Chickaloon River. The lease was procured for the company by Lars Netland, engineer, in February, 1917, and the following July W. A. Gompertz, superintendent, and Mr. Netland returned and made an examination of the property and reported to the company. Development work was started in November, 1917, and has since continued with a small crew of men.

The underground developments to date consist of three tunnels, with an aggregate of 1,350 feet; one diamond-drill hole, 658 feet deep, and another one being drilled. The mine camp is at the mouth of Louise Creek, a small stream that enters Chickaloon River at the sharp bend 1½ miles above its mouth.

GEOLOGY.

The tract that is being explored for coal is occupied by shale and sandstone of the Chickaloon formation. The rocks lie in a monoclinal block, in which the beds strike from east to northeast and dip north to northwest at angles of 35° to 60°. The beds are apparently less disturbed than at the Chickaloon mine; no faulting of any magnitude occurs, and the folding is more uniform than on unit 12.

The rocks cut by the bore holes and tunnels on unit 11 correspond approximately in stratigraphic position to the beds exposed in the workings of the Chickaloon mine. Tunnels 1 and 3 together cut across a section which is believed to be continuous, except for a possible small gap or duplication between the face of tunnel 3 and the mouth of tunnel 1. This section extends from the railroad track along the river nearly to the gabbro mass that makes up the hill below United States land monument 3. The drill hole cuts a section a part of which is believed to be stratigraphically higher than the beds exposed in tunnels 1 and 3.

The stratigraphic sections are shown graphically in Plate V. The drill hole was driven at an angle of 50°, as nearly perpendicular to the bedding of the rocks as possible, so the section with the exception of the gravel and igneous rocks approximates the stratigraphic section.

The correlations suggested between the beds in the tunnels and those at the Chickaloon mine, sections of which are shown in Plate V, seem possible, but much doubt exists concerning any correlation between the rocks of the tunnels and the drill hole. Stratigraphically the drill section appears to extend higher than the other, but between the two localities there is a concealed interval of 1,500 feet and the structure is inferred from outcrops along the river.

The lower coal group of beds, which includes beds A to G in the workings of the Chickaloon mine, is believed to correspond to the beds of carbonaceous shale which are shown in the lower half of the coal section exposed in tunnel 3 of the Chickaloon Coal Co. The coal beds exposed near the mouth of tunnel 3 are correlated with beds H, I, J, and K of the Chickaloon mine, and coal bed L is believed to correspond to the bed of carbonaceous shale near the mouth of tunnel 1 or the small bed of coal above it.

If these suggested correlations made between the rocks at the Chickaloon mine and those exposed in the workings of the Chickaloon Coal Co. are correct, the coal beds all diminish in size toward the west from the Chickaloon coal mine, and some of them disappear entirely. This appears to limit the coal-bearing tract of the Chickaloon mine on the west. This fact does not condemn the property of the Chickaloon Coal Co., for the area prospected is only a small part of the leasehold, which should be tested for other possible coal-bearing areas to the west and north of the present workings.

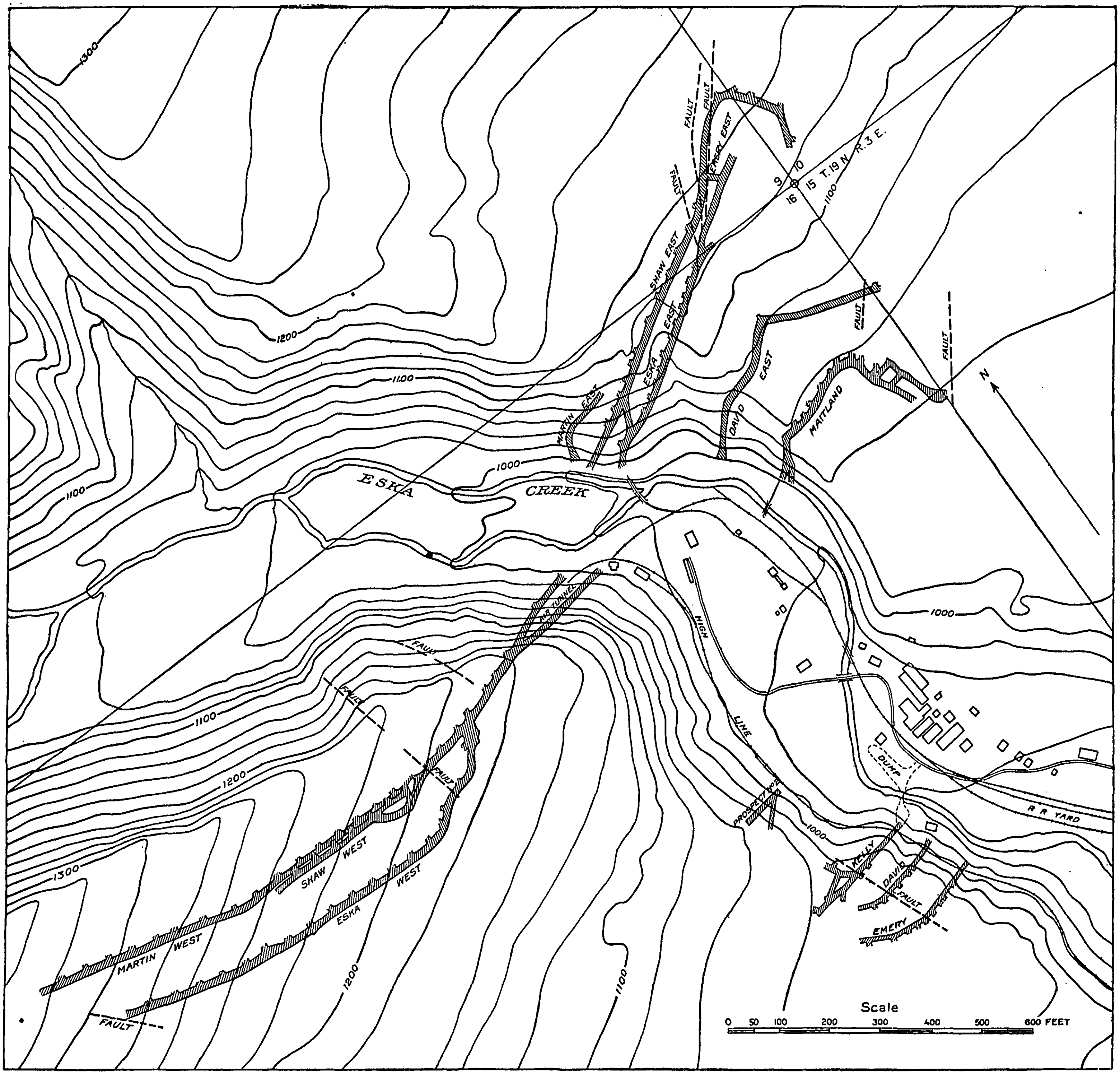
ESKA MINE.

LOCATION AND DEVELOPMENT.

The Eska mine is 60 miles from Anchorage, on leasing unit 7, and is reached by a short spur that connects with the Matanuska branch of the railroad at Sutton.

The coal outcrops at Eska occur on both banks of Eska Creek, which cuts across the strike of the coal-bearing rocks. The mine is being developed by drift tunnels extended along the coal beds a few feet above the level of the creek. Ten such openings have been made on coal beds, and three of them are working entries. Six workable beds of coal are being mined, known as the Martin, Shaw, Eska, Emery, David, and Kelly or Maitland. As most of these beds have been identified on both sides of Eska Creek, the suffix east or west is used with the name of the bed or entry to indicate the side of the creek on which the bed occurs or the entry is driven.

Development at Eska was started in January, 1917, by the Eska Creek Coal Co. The first mining was done on the Emery, David, and Kelly beds on the west side of Eska Creek. Entries were driven along these coal beds to a fault which cuts off the coal in all three tunnels, and the coal above drainage level was mined out and the workings abandoned. The Eska Creek Coal Co. also started entries on the outcrops of the Eska and Maitland beds on the east side of Eska Creek.



TOPOGRAPHIC MAP OF COUNTRY AROUND ESKA COAL MINES, SHOWING FAULTS.

The Alaskan Engineering Commission has opened up the Eska, Shaw, and Martin beds on both sides of the creek and the Emery, David, and Maitland on the east side. About 2,300 feet of churn drilling was done in 1918 to prospect the ground east of Eska Creek, and a prospect shaft was put down to explore one of the beds cut. Another prospect is a tunnel being driven to open the David and Emery beds west of Eska Creek on the north limb of the syncline (Pl. VI). The Eska, Shaw, and Martin beds west of the creek are mined from the Eska West tunnel, the Shaw, Eska, and Emery beds east of the creek from the Eska East tunnel, and the Maitland from the Maitland tunnel.

Prospecting on some coal beds which crop out about three-quarters of a mile west of Eska was postponed until spring on account of unfavorable weather.

A narrow-gage line extends 2,500 feet from the Eska West tunnel to the cleaning plant, which was installed in the fall of 1918. The coal passes over a $\frac{3}{4}$-inch grizzly; the undersize goes direct to the railroad cars and the oversize to the picking table, from which the waste is hand-picked and the lump passes to the same car as the undersize from the grizzly, or to a separate car as desired.

Besides the office and usual mine buildings a number of cottages have been put up on the Eska town site southeast of the mine workings for the use of the families and the office and technical force of the mine.

GEOLOGY.

STRATIGRAPHY.

The coal-bearing rocks at the Eska mine occur in an open syncline whose axis strikes across Eska Creek near the center of the mine camp. The coal beds have been identified on both limbs of the syncline and on both sides of the creek, which crosses the coal tract and divides it into two parts. Stratigraphically the coal beds occur in two groups of three beds each, separated by a thick interval of sandstone and shale. Although the coal and the inclosing sediments vary in character and thickness from place to place, the coal beds have prominent markers which are persistent enough to identify the beds with little doubt wherever they have been opened. The following stratigraphic section is generalized from data obtained on both limbs of the syncline on the west side of Eska Creek:

Generalized section of coal measures at Eska.

	Feet.
Shale in trough of syncline; top concealed	10
Coal	2
Sandstone	47
Coal (Kelly bed)	10
Shale with a little sandstone	38
Coal (David bed)	3½
Shale, largely nodular	52
Coal (Emery bed)	5½
Sandstone and shale	286
Coal (Eska? bed)	3
Shale	29
Coal (Shaw bed)	5
Shale and ironstone	11
Coal (Martin bed)	4½
Shale with thin beds of coal	100+

The thickness of the interval between the Emery and Eska beds is undetermined. This interval, where measured, is partly covered with slide, which possibly conceals faults. Where the bed doubtfully called the Eska crops out it is badly burned, so that its identity is not certain. It is believed to be the Eska, as it is the first exposed coal bed below the Emery and is evidently one of the lower group of coal beds. The interval between the upper and lower groups of beds is also concealed on the north limb of the syncline and on both limbs on the east side of the creek.

Above the coal beds that are being opened at the Eska and separated from them by an unknown interval of probably several hundred feet is another coal group containing several beds of coal.

The detailed section given below was measured along the south limb of the syncline on the west side of Eska Creek.

Stratigraphic section of rocks exposed on south limb of syncline on west bank of Eska Creek.

	Ft.	in.
Shale in trough of syncline; top concealed	10	
Coal	2	
Gray sandstone	32	
Yellow sandstone	15	
Coal (Kelly bed)	10	
Shale	19	
Sandstone	10	
Gray nodular shale	5	
Shale	4	
Coal (David bed)	3	6
Carbonaceous shale	6	
Ironstone		3
Carbonaceous shale	1	2
Gray shale		4
Ironstone		6

	Ft.	in.
Gray shale with ironstone nodules	3	6
Carbonaceous shale		6
Gray shale with ironstone nodules	18	
Sandstone and shale	5	
Shale with ironstone nodules	12	
Shale with coal	5	
Coal (Emery bed)	5	6
Shale	38	
Shaly sandstone	3	
Thin-bedded sandstone	10	
Massive sandstone	36	
Carbonaceous shale with clay seam	2	
Shale with some sandy beds (partly concealed)	40	
Thin-bedded sandstone	10	
Massive sandstone	32	
Soft decomposed sandstone	13	
Carbonaceous shale	1	
Shale	30	
Concealed (probably shale)	15	
Shale	46	
Coal (Eska? bed)	3	
Shale.		

On the north limb of the syncline the beds of the upper part of the section are largely concealed on both sides of the creek. The following section of the cliff above the portal of the entry driven on the Eska West is adapted from notes of G. C. Martin:

Section on cliff above Eska West entry.

	Ft.	in.
Sandstone (cliff)	75	
Soft sandstone	9	
Shale with a little coal	2	
Concealed shale and sandstone	64	
Shale	16	
Coal (Eska bed)	3	
Shale with coal streaks	5	
Shale	14	
Carbonaceous shale	2	
Shale and coal	5	
Coal (Shaw bed)	5	
Shale	5	
Ironstone	1	
Shale	5	
Coal (Martin bed)	4	6
Shale	5	
Coal	2	2
Shale with ironstone concretions	23	

Above the sandstone that makes the cliff is a concealed interval, which from its wash is judged to contain both shale and sandstone. The Emery bed is probably at about this horizon but does not crop out. As shown later, there is reason to believe that at this place it may be cut out by faulting. Above this concealed interval the David and Kelly beds are exposed but are too crushed and burned on the surface to give a good idea of their character.

Below this section is 25 feet of alternating thin beds of coal and shale overlying about 80 feet of shale and ironstone carrying a few thin coal beds. None of these appear to be worth opening up, as the beds are thin and are considerably broken by faulting.

On the east side of Eska Creek the coal beds on the north limb of the syncline have been correlated with the known beds on the other side of the creek. The equivalent of the Kelly bed on this side of the creek, however, is known as the Maitland. This naming was used before the identity of the beds was established and is still retained. On the south limb of the syncline on the east side of Eska Creek the rocks on the hillside are largely concealed, but coal beds have been opened which correspond in position and character to the Maitland, David, and Emery. Beds also occur which occupy about the position of the Eska, Shaw, and Martin, so it appears that the section exposed across Eska Creek is present here also.

It is evident, however, that the inclosing rocks vary greatly from place to place along the strike. Above the Eska West bed on the north limb of the syncline there is a section containing a stratigraphic thickness of 165 feet (and possibly much more in the concealed interval) of sandstone with very little shale. Whether or not the burned bed of coal on the sharp curve of the high line is correctly correlated as the Eska bed, the fact remains that on the south limb of the syncline the reverse is true and shale predominates. This, however, may be due in part to undetected faulting in the concealed part on either or both limbs of the syncline. Sandstone also seems to be less abundant on the east side of the creek than on the west side. The sandstone that overlies the Kelly bed on the west side of Eska Creek has a stratigraphic thickness of 47 feet, and the corresponding member above the Maitland is only about 25 feet thick.

The massive sandstone that makes up the cliff above the Eska West entry does not appear on the east side of the creek in a corresponding stratigraphic position. This absence, however, is due, at least in part, to faulting. On the south limb of the syncline also there appears to be less sandstone than in the corresponding members on the west side of the creek, but here, as in other places, this may be due partly to faulting.

The stratigraphic position of these coal-bearing beds in the Chickaloon formation is not certain. Beneath the coal beds of the Eska mine there is at least 200 feet of sedimentary rock and possibly many times as much. The base of the Chickaloon formation is not exposed in this vicinity, and the nature of its contact with the underlying Cretaceous rocks is not known. The coal outcrops recently found three-quarters of a mile west of Eska are evidently much higher stratigraphically and apparently are near the base of the Eska conglomerate of Wishbone Hill. This horizon may correspond to that of the coal-bearing rocks at the Baxter mine on Moose Creek.

THE COAL BEDS.

Martin bed.—The Martin bed is about 4½ feet thick and is made up of two benches with a thick parting of shale. An underlying bed of coal, 2 feet thick, is separated from the Martin bed by 5 feet of shale.

Section of the Martin bed in the Martin West tunnel.

	Ft.	in.
Hanging wall, carbonaceous shale.		
Coal	2	
Shale	1	1
Coal	1	5
Footwall, shale.		

Shaw bed.—The Shaw bed is from 4 to 5 feet thick and is characterized by three very distinct markers of yellow clay and shale.

Section of Shaw bed in room 5, Shaw West tunnel.

	Ft.	in.
Hanging wall, shale.		
Coal		10
Shale		2
Coal		8
Sandy shale		1
Coal		8
Shale		1
Coal	2	
Footwall, shale.		

Section of Shaw bed in Shaw East tunnel.

	Ft.	in.
Hanging wall, carbonaceous shale and bone.		
Coal	1	2
Shale parting		1
Coal	1	
Shale		2
Coal		7
Shale		5
Coal and bone	1	10
Footwall, shale.		

Eska bed.—The Eska bed ranges in thickness from 2½ to 3 feet and is underlain by 5 feet of carbonaceous shale. Above the coal is 6 inches or more of carbonaceous shale with a very characteristic clay marker.

Section of Eska bed in Eska West tunnel.

	Ft.	in.
Hanging wall, carbonaceous shale with clay marker		6+
Coal	3	
Bone and carbonaceous shale	5	
Footwall, shale.		

Section of Eska bed in Eska East tunnel.[1]

	Ft.	in.
Hanging wall, shale.		
Shale and bone		7
Coal, woody structure, with thin sulphur bands		9
Compact shale marker		1
Medium-hard black coal, woody structure		8
Parting.		
Coal		1
Coal, woody structure, with bone and sulphur bands	2	
Footwall, shale.		

Emery bed.—The Emery bed contains from 4 to 5½ feet of coal, with some bone and shale. The part which is being extracted in mining is from 2½ to 4 feet thick and averages about 3 feet.

Section of Emery bed at face of Shaw East tunnel.

	Ft.	in.
Hanging wall, shale.		
Coal	1	
Bone and coaly shale		10
Clay		2
Coal and shale		6
Coal	1	5
Parting.		
Coal	1	6
Footwall, carbonaceous shale.		

Section of Emery bed on west bank of Eska Creek.

	Ft.	in.
Hanging wall, shale and coal.		
Coal		11
Shale		1
Coal		5
Soft shale		1
Coal	2	6
Shale		1
Coal	1	

David bed.—The David bed is from 2½ to 3 feet thick. It has two benches of coal with a thin marker of yellow shale.

Section of David bed on west bank of Eska Creek.[2]

	Ft.	in.
Hanging wall, shale.		
Coal	2	6
Yellow shale		1½
Coal		10

[1] Smith, S. S., Alaskan Engineering Commission, Mining Dept., Report for year ending Dec. 31, 1917.

[2] Martin, G. C., Geologic problems at the Matanuska coal mines: U. S. Geol. Survey Bull. 692, p. 271, 1919.

Section of David bed in David airway.[1]

	Ft.	in.
Hanging wall, compact shale.		
Clod and shale with streaks of coal		11
Niggerhead		1½–2
Hard black friable coal, well-developed cleat	1	10
Bone		2
Footwall, shale.		

Kelly bed.—The Kelly bed contains a lower bench, a thick parting of bony coal and shale, and an upper bench, which average, respectively, 3, 5, and 2 feet in thickness.

Maitland bed.—The Kelly bed is known on the east side of Eska Creek as the Maitland bed. The lower bench, from which coal has been mined, is from 2½ to 4 feet thick and averages about 3 feet. The following section was measured by Sumner S. Smith:

Section of Maitland bed in Maitland tunnel.

	Ft.	in.
Hanging wall, compact shale and sandstone.		
Soft shale with streaks of coal		3
Compact brown shale marker		¾
Black friable coal	1 to 2	6 to 2
Bone, coal, and clod	4–7.	
Black friable coal	2 to 3	6 to 6
Bone		2
Footwall.		

Coal beds west of Eska mine.—About three-quarters of a mile west of the Eska mine some coal beds are being prospected. Two open cuts show the following sections:

Section on tributary of Eska Creek three-quarters of a mile west of Eska mine.

	Ft.	in.
Coal with three shale partings	7	
Carbonaceous shale	2	6
Coal	3	
Concealed interval.		
Shale	3	
Coaly shale	2	
Coal	1	10
Parting		4
Coal (dirty)	2	4
Shale		7
Coal		4

[1] Smith, S. S., Alaskan Engineering Commission, Mining Dept., Report for year ending Dec. 31, 1917.

	Ft.	in.
Carbonaceous shale	1	6
Coal		6
Coaly shale		6
Shale		6
Coal		10
Shale		4
Coal	1	
Coaly shale	3	

STRUCTURE.

The coal-bearing rocks at the Eska mine lie in an open syncline whose axis trends across Eska Creek with a strike of about N. 60° E. and pitches slightly southwest. East of the creek the trough of the syncline is very open, and the rocks of the north limb are flat lying. The south limb is largely obscured by débris. On the west side of the creek the open folding of the syncline is somewhat disturbed on the north flank by faulting, which has thrown the Kelly and David coal beds and the adjacent strata into a steep attitude. This axis lies almost in line with the synclinal axis of Wishbone Hill and may be on the same fold. Structure sections are shown in figure 3.

Faulting is very evident in this coal tract. The rocks bordering Eska Creek appear to be in a downthrown block, which itself is broken by faults striking at various angles, as opposed to the orderly and parallel arrangement of the main faults at Chickaloon. The tract now being mined is bounded on the north by a fault zone, beyond which the ground is broken, and it is doubtful whether mining could be carried on profitably. The coal-bearing area is probably limited on the east also by a fault, which is not known to exist but which is predicated to explain the absence of the Tertiary arkose beds between the Chickaloon formation and the Cretaceous rocks east of Eska Creek. To account for this it seems necessary to accept the existence of a fault of considerable dislocation and a relative downward movement of the block west of the fault. Within the coal tract there is not a coal bed now being opened that has not been faulted. Most of the faults encountered, however, are not great, and as a rule the faulted part has been found without much difficulty.

At 280 feet from the mouth of the Eska West tunnel a fault has offset the Eska bed toward the south for a horizontal distance of 50 feet and brought the faulted ends of the Shaw and Eska beds together, so that the entry passes from one bed to another without any perceptible break. About 180 feet west of this point a parallel fault has brought the Shaw and Martin beds together in a similar manner. The horizontal displacement along the eastern fault is 50 feet, and that along the western fault is 60 feet. Near the face of the Eska West tunnel a fault striking northwest cuts the coal bed. The

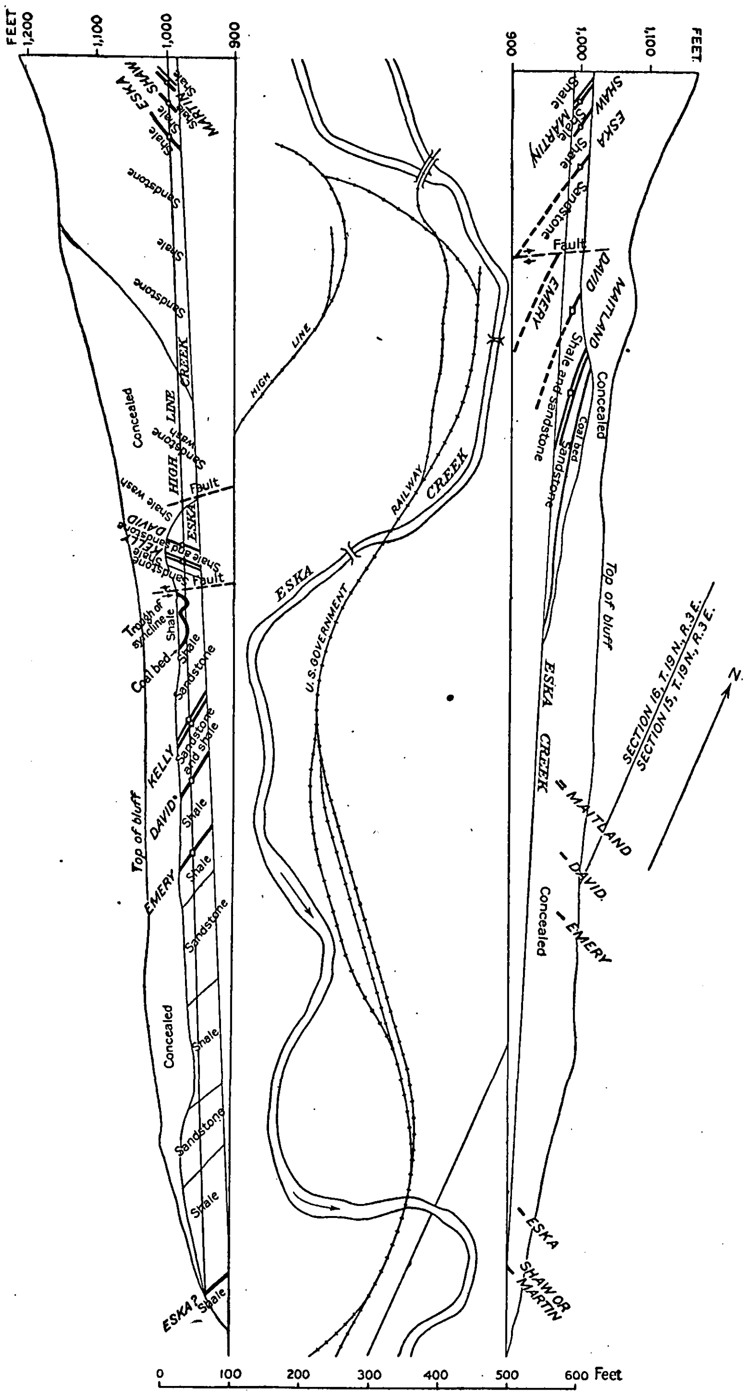


FIGURE 3.—Structure sections at Eska coal mine.

relative movement of the southwest block appears to have been toward the northwest, but the movement evidently was not great, and the fault has either played out or curved toward the south, for it does not intersect the Martin West tunnel, which it would do if it maintained the direction it has in the Eska West. The extension of the eastern fault toward the south is indicated by its general alinement with faults in prospect tunnel 2 and the old Kelly, David, and Emery workings.

The most prominent fault is one that extends northeast across all the workings on the east side of Eska Creek and possibly is found on the other side of the creek also. The relative movement of the block southeast of the fault has been downward, and the fault has cut off the Eska, Shaw, and Martin beds in the workings and brought the Emery bed against the Shaw and Martin. On the bluff along Eska Creek the Emery bed is cut out by this downward movement, but it should be found in depth below the David bed on the southeast side of the fault. This fault limits also the workings of the Maitland bed on the northwest. The southwest projection of this fault intersects the west bank of Eska Creek in the concealed interval just north of the locality where the David bed crops out. Faulting at this locality is regarded as probable, to account for the missing Emery bed, which normally should be found here.

The only scale by which to measure the amount of this faulting is the stratigraphic column, especially the interval between the lower and upper groups of coal beds. Unfortunately this interval has not been accurately determined. On the east side of Eska Creek one limb of the syncline is covered with débris and the other is disturbed by faulting. On the west side this interval is largely concealed on the north limb and probably also is faulted. On the south limb the Eska or underlying beds have not been positively identified, but between a bed that is regarded as the Eska and is quite evidently one of the lower groups of beds and the Emery bed there is a measured section of 286 feet of sediments. Some undetected faulting may occur in the concealed interval, but this figure is believed to be approximate for this stratigraphic interval. Using this as a scale and allowing for the additional thickness between the Eska and Martin and also for the inclination of the beds there appears to have been a vertical dislocation of 350 to 400 feet near the face of the Shaw East tunnel, where the Martin and Emery beds are brought together by this fault. The vertical movement along the fault plane is evidently less on the bluff near the mouth of the East David airway, as the fault shows diminishing displacement toward the southwest.

Just south of this locality a fault that crosses prospect tunnel 2, which is now being driven to open up the David and Emery beds, is about in line with the fault on the old Kelly, David, and Emery tunnels on the south flank of the syncline and also with the east fault in the Eska West tunnel, and it is not improbable that all three lie along a single break. They agree in general strike and position, and two of them agree in the relative downward movement of the block east of the fault, which has resulted in a horizontal displacement of the beds on the north limb toward the north and of the beds on the south limb toward the south. In prospect tunnel 2 the David bed is faulted. The relative direction of movement has not been determined, but the faulted part is to be looked for south of the break.

The existence of a fault just south of prospect tunnel 2 is inferred to explain the absence of about 30 feet of the massive sandstone member which overlies the Kelly bed on the south limb of the syncline. A number of minor faults occur. The Maitland workings on the southeast are bounded by a dislocation of undetermined amount. A shaft put down near bore hole 33 showed a fault cutting off a coal bed. A fault intersects the south bank of Eska Creek about a quarter of a mile above the mouth of the Eska West tunnel and appears to trend south toward the present face of the Martin West tunnel but evidently has not been recognized in any one of the underground workings.

DOHERTY MINE.

The Doherty mine is on the west bank of Moose Creek about three-quarters of a mile from the mouth of the creek and 50 miles from Anchorage. The mine was opened in 1916 by the Doherty Coal Co., and its product was sold to the Alaskan Engineering Commission and to individuals in Anchorage.

The mine is developed by a drift tunnel from which the coal was mined nearly to the surface. A shaft was then sunk, and mining was continued on a lower level. The coal was screened and cleaned in a hand-picking plant at the mine and hauled 3,000 feet over a narrow-gage line to the mine bunkers at Moose Creek for rail shipment to Anchorage.

The section given below was measured in 1917 by Martin,[1] who says:

If the operators of this mine are able to compete with other producers they will probably be able to find a moderately large area of workable coal in the vicinity of their mine. No structural disturbances have thus far been discovered. The mine is situated on the north flank of a small local basin or else on a southward-dipping fault block.

[1] Martin, G. C., Geologic problems at the Matanuska coal mines: U. S. Geol. Survey Bull. 692, p. 282, 1919.

Section of coal in Doherty mine.

	Ft.	in.
Sandstone (roof).		
Bone ("cap rock")	1	1
Coal	1	11
Bone		1
Coal	1	3
Carbonaceous shale ("black dirt")		3
Shale (floor).		
Strike N. 67° E., dip 45° SE.		

The coal shipped from this mine was of low grade on account of the high ash content resulting from the lack of adequate cleaning, and it never proved to be satisfactory. No coal was mined here in 1918.

BAXTER MINE.

The Baxter mine is on Moose Creek about 4½ miles from Moose Creek station, on the Matanuska branch of the railroad. The mine is on a tract comprising leasing units 2 and 3, the lease for which was granted to Oliver La Duke, Henry Baxter, C. C. Harcy, and W. A. Smith early in 1917. Mining operations began in December, 1917, and continued until April, 1918, as long as it was possible to sled the coal to the railroad at Moose Creek. The output was sold in the local market and to the Alaskan Engineering Commission. A little development work was continued during a part of the summer of 1918, but the mine remained idle the rest of the year. The coal-bearing rocks crop out on the east bank of Moose Creek on a prominent bluff on which the coal is exposed for several hundred feet. The most conspicuous bed, known as the "big bed," is 11 feet thick and occurs in two benches 4 and 7 feet thick with a shale parting of 2 inches. Aside from this shale parting the bed is comparatively free from impurities, and the coal has proved to be very popular for domestic use. The mine was opened with the hope of making an immediate production, and the size and purity of the "big bed" offered such promising possibilities of maintaining a considerable tonnage from the start of mining operations that the difficulties of mining it, due to unfavorable structural features, were not properly taken into account.

That the rocks exposed along Moose Creek are faulted and not in place is evident from their broken appearance and the detached blocks of coal, and from the discordance between their dip and strike and the attitude which would be normal along this limb of the Wishbone Hill syncline, and even from the discordance between the creek exposures from place to place.

The mine is being developed by three tunnels driven into the bluff to open up the "big bed." (See fig. 4.) Tunnel 1 is about 300 feet long. In places it cuts across the formation, and in places it drifts along coal beds in an attempt to prospect the broken ground.

It is connected by a number of workings with an upper level 40 feet higher, which comes to the surface at the air shaft. Tunnel 1 cuts diagonally across the strike of the beds for 40 feet and then cuts

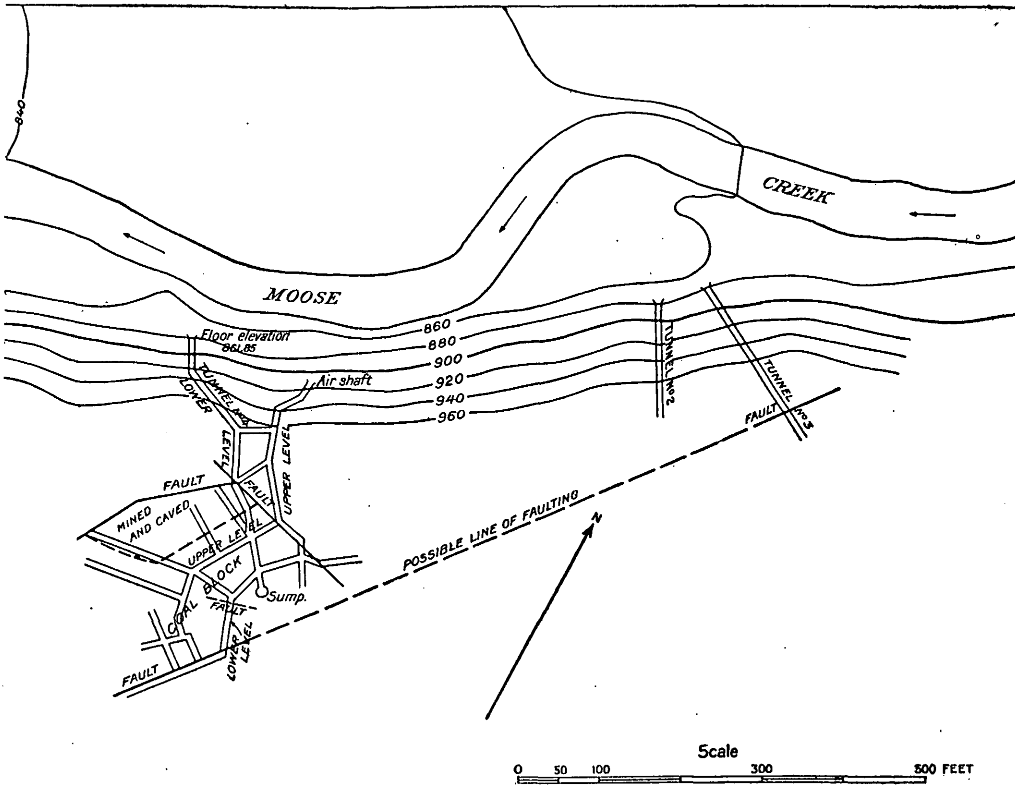


FIGURE 4.—Map of Baxter mine showing faults.

a coal bed, which is opened by a drift for 95 feet to a fault that cuts the coal off. From this point the tunnel again cuts diagonally across the strike of the formation for 170 feet and intersects two small beds of coal and the "big bed" for which the mine is being developed. The following section is exposed:

Section of coal-bearing rocks cut in tunnel 1, Baxter mine, Moose Creek.

		Ft.	in.
Shale, hanging wall.			
Coal ("big bed")	Coal	4	
	Shale		2
	Coal	7	
Shale		14	
Coal		3	
Bone		1	
Shale		2	8
Bone		1	6
Coal		2	6
Bony coal		2	6
Shale, footwall.			

These same beds are exposed along the stream a short distance northeast of the entry. The relation of the small bed of coal exposed near the mouth of the tunnel to the section given above is not known, as the two are separated by a fault.

The "big bed" has been opened for distances of 130 feet and 200 feet by drifts extended, respectively, from the lower and upper levels. In these distances the bed is considerably broken and is cut off on both the northeast and southwest by faults, beyond which it has not been explored. The most prominent fault is exposed at the southwest end of the drift from the lower level. At this place it strikes N. 40° E. and dips 42° SE. and has faulted black slate against massive conglomerate. This is probably the overlying Eska conglomerate and if so indicates normal faulting, with a downthrow of the conglomerate block southeast of the fault. The fault that limits the coal at the northeast face of the workings strikes about N. 75° W. and appears to be about vertical. The movement along the fault has not been very great, as shown by the relative position of the two coal beds in the lower level below the "big bed" and the position of the same beds on the surface north of the fault. The principal movement of the block north of this fault appears to have been a breaking over and sliding down toward the stream of a block that includes the "big bed."

Tunnel 2 cuts a number of small burned coal beds. Tunnel 3 extends southeastward for 220 feet. About 70 feet from the portal it intersects a small bed of coal and follows it nearly to the face, where it is cut off by a fault that has brought the conglomerate against the coal-bearing shales. This break is directly below the prominent conglomerate cliff, suggestive of a fault scarp, that caps the bluff above the river, and it also lies on the northwesterly projection of the line of faulting in the southwest end of the workings in tunnel 1, where conglomerate is faulted downward against shale. These facts suggest that the two breaks may be on the same line of dislocation. The conglomerate at both places relatively moved downward and carried the coal-bearing beds downward also.

To prospect for the coal-bearing rocks it will be necessary to extend the workings downward along the fault the amount of the normal displacement along this plane. The amount of this movement has not been determined or even estimated, as there appear to be no data on which to base an estimate. It will have to be determined by actual exploration.

The location of this bed southeast of the fault is not believed to be an unsurmountable difficulty, or one which should discourage the active development of the mine. The amount of displacement may be several hundred feet, but southeast of the line of faulting, beneath the massive conglomerate, the rocks, including the coal-bearing strata, are probably much less fractured than those exposed by the present workings.

The coal-bearing rocks at this mine lie within the Chickaloon formation near its contact with the overlying Eska conglomerate. The relation between the conglomerate and that part of the Chickaloon formation in which the coal occurs is obscured by faulting. As the extent of this faulting is not believed to be great, it appears that the coal lies near the top of the formation. The Chickaloon rocks exposed at this place occur in a narrow strip that lies between the Eska conglomerate of Wishbone Hill and the concealed area of the swampy ground to the northwest.

Wishbone Hill is a syncline that pitches toward the southwest. The trough of the syncline extends northeastward along the crest of the hill, and the Chickaloon rocks dip into the hill from both the northwest and the southeast. The synclinal fold extends southwestward as far as Moose Creek. It is thus inferred that a part of the concealed area northwest of Moose Creek is underlain by rocks of the Chickaloon formation, which structurally should occupy this position between the Eska conglomerate of Wishbone Hill and the Tertiary arkose of Arkose Ridge. The rocks of this concealed area thus may contain beds of coal, but probably they are complexly folded and faulted. The chances of developing workable beds of coal appear to be less favorable on this side of Moose Creek than on the other side in the present workings.

LODE DEVELOPMENTS IN THE WILLOW CREEK DISTRICT.

By Theodore Chapin.

INTRODUCTION.

The region popularly known as the Willow Creek mining district comprises an area of about 40 square miles in the Talkeetna Mountains and is about 12 miles from the head of Knik Arm, one of the branches of Cook Inlet. The region is tributary to both Susitna and Little Susitna rivers and takes its name from Willow Creek, one of the principal streams of the area, although none of the productive lode properties are on Willow Creek itself.

This paper on the recent developments is based on a few days' work in September, 1918, in which the producing properties were hurriedly visited incidentally to the collection of data on mineral production.[1] An early fall of snow prevented the examination of surface prospects which otherwise would have been visited. No attempt is here made to describe all the mines and prospects in the district, only those where production has been maintained being mentioned. The location of the mines and prospects is shown on figure 5.

The Survey is indebted to many persons for information used in this report, especially to Messrs. N. D. Bothwell, James McDonald, B. Pinder, W. R. Hocking, W. S. Horning, W. P. Martin, Charles Bartholf, Henry Emard, Sam McMelan, Theodore Pilger, and Milo Kelly.

The Willow Creek district may be reached by wagon road from Wasilla, a station on the Government railroad 16 miles from the Fishhook Inn, on the edge of the Willow Creek district, and 55 miles from Anchorage. It may also be reached by a slightly shorter route by trail from Moose Creek, a station on the Matanuska branch of the railroad.

The Willow Creek district is being exploited for its gold lodes, which occur as fissure veins in quartz diorite. The geologic features are favorable for depth of veins and permanence of gold content.

[1] For a detailed description of the district and reports of progress of mining see Capps, S. R., The Willow Creek district, Alaska: U. S. Geol. Survey Bull. 607, 1915; also U. S. Geol. Survey Bull. 642, p. 195, 1916, and Bull. 692, p. 177, 1919.

The region has not received the attention of prospectors or investors that the geologic conditions would seem to justify, however, and development has been retarded by a number of adverse conditions, some of which have lately been partly overcome and others, it is hoped, will be improved in the near future. At present the outlook is bright for a continued development of the region and a permanent camp with increased production.

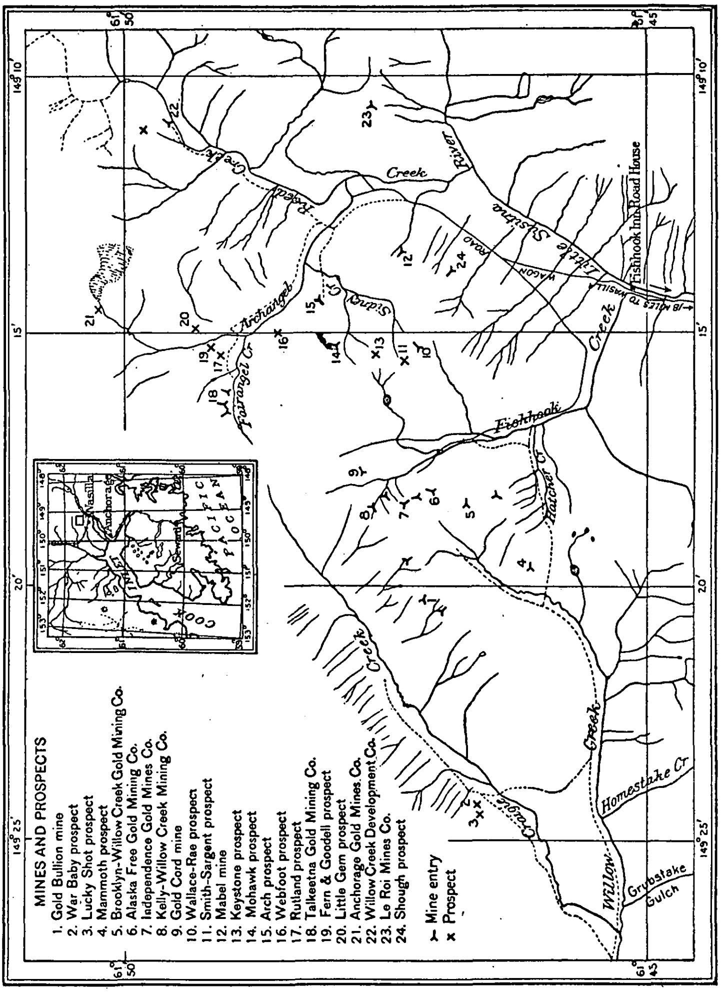


FIGURE 5.—Map of Willow Creek district showing location of mines and prospects.

The high cost of transportation to the mines, caused by the remoteness of the region, has been somewhat reduced by the construction of the Government railroad. Previous to its operation supplies were brought from Knik, a distance of about 31 to 35 miles. Machinery and supplies are now sledded in during the winter from Houston and freighted by team and motor truck during the summer from Wasilla, both stations on the railroad. The winter freight rate from Houston is 2½ cents a pound, and the summer rate from Wasilla ranges from 1½ to 2½ cents.

One of the main obstacles to successful mining in this district is the short operating season—three to five months. This is governed mainly by the period during which it is possible to obtain power for milling. Power used at the mills is derived principally from water-driven Pelton wheels and turbines and is usually generated at the point of utilization. The water supply is drawn from near-by small streams, lakes, or artificial reservoirs, which are frozen or considerably diminished in flow from about September to May. Dependence on this source of power necessarily limits the operation of the mills to the short open season of 90 to 130 days and imposes a heavy duty on the investment. The development of cheap electric energy for winter use is an imperative need of the district. To supply this need a hydro-electric power plant on Little Susitna River or in the canyon of Willow Creek has often been suggested. A plan which seems more feasible is the erection of a central power plant near some supply of coal. An efficient plant might be one designed to utilize the producer-gas principle, which involves the complete gasification of the coal, with or without the recovery of the by-products (tar, ammonium sulphate, and light oil), and a resulting carbon residue suitable for fuel. With such a plant, which could utilize lignite or even high-ash mine refuse, the gas evolved could be used directly for fuel in the generation of electric energy for transmission to the mines. The carbonaceous residue resulting from the gasification of the coal is convertible into briquets of smokeless fuel, probably of higher grade than any coal now locally used in Anchorage. The recoverable by-products that might be used locally are tar for road dressing, ammonium sulphate for fertilizer, and benzol, a product of the light oil, for motor oil. Other by-products are dyes, various useful chemicals, and toluol, which is essential in the manufacture of high explosives.

Another urgent need of the district is the consolidation of some of the smaller properties, which to date have had a struggling existence but might be run at a profit by the reduction of overhead expenses and the advantage of efficient management and technical advice, which have been sadly lacking in the past at many of the properties.

MINING IN 1918.

Mining in the Willow Creek district in 1918 was conducted on about the same scale as during the previous year. Five mines were operated and yielded $269,624 worth of gold and $724 worth of silver. The lodes of this district have produced to date gold to the value of $1,602,380, as shown in the subjoined table.

Gold and silver produced at lode mines in Willow Creek district, 1908–1918.

Year.	Gold.		Silver.	
	Quantity (ounces).	Value.	Quantity (ounces).	Value.
1908	87.08	$1,800	6.88	$3.64
1909	1,015.87	21,000	80.25	41.73
1910	1,320.15	21,290	104.29	56.31
1911	2,505.82	51,800	197.95	109.91
1912	4,673.02	96,600	369.07	226.97
1913	4,883.94	100,960	385.83	233.42
1914	14,376.28	297,184	1,330.00	735.00
1915	11,961.55	247,267	811.00	421.00
1916	14,473.46	299,193	1,468.00	967.00
1917	9,466.17	195,662	713.00	586.00
1918	13,043.05	269,624	724.00	724.00
	77,806.39	1,602,380	6,190.27	4,104.98

During the summer of 1918 a great deal of interest was manifested in the district, several sales of mining property were recorded, a great number of examinations were made by mining men, a mill was in process of erection on one of the properties, and a new mining company was incorporated in Anchorage.

Interest was further stimulated by the reported discovery of platinum in the gold lodes. Samples collected by the writer from two of the mines were submitted to the Geological Survey for assay, but no platinum was found. This result is not surprising, as the geologic associations of the Willow Creek lodes do not favor the occurrence of platinum, which although found in siliceous lodes in small quantities is usually restricted to magnesian plutonic rocks, especially the more basic rocks, such as dunite and pyroxenite. The only known basic intrusive rocks in this district are some gabbros that cut the granites in the eastern part of the district. These are green rocks found as local patches in the granite. None of the reported platinum-bearing ores come from these rocks, nor is there any evidence that they carry platinum.

LODES.

The Willow Creek mining district is being developed mainly for gold, which occurs in fissure veins in quartz diorite and related rocks that are intrusive into mica schist. The gold occurs mainly as free gold in a quartz gangue, which also carries various sulphides. About 90 per cent of the gold obtained is recovered by amalgamation and the remainder by cyanidation of the sands and tailings.

The hard-rock formation of the Willow Creek district are mica schist and chlorite-albite schist cut by granitic rocks, mainly quartz diorite, and overlain by arkose, shale, conglomerate, and sandstone. The quartz diorite is intrusive into the mica schist, but both schist and diorite are unconformably overlain by the arenaceous sediments. The granitic rocks are provisionally correlated with the Coast Range intrusive rocks and in this general region are probably of Lower or

Middle Jurassic age. The mica schist is thus Jurassic or earlier and is probably much older. The arenaceous sediments are of Eocene age and therefore have not shared in the mineralization, which is believed to be genetically related to the invasion of the mica schist by the quartz diorite.

The proved productive zone is in the intrusive rock, which thus appears to be the best ground for future prospecting. The sandstone and associated sediments were deposited later than the mineralization of the granitic rocks and evidently do not carry any valuable metallic deposits.

MINES AND PROSPECTS.

GOLD BULLION MINE.

The Gold Bullion mine, the most constant producer in the district, is operated by the Willow Creek Mines. The mine is at an elevation of 4,500 feet on the divide between Craigie and Willow creeks, and the mill is on Craigie Creek 1,500 feet below the mine.

The mine is developed on a single vein that follows a very persistent fissure, which strikes about S. 10° W. and dips 14° NW. The vein filling, however, is less regular and in some places pinches to a mere stringer and in others splits up into three veins. The vein is broken by three main faults, which strike from S. 10° E. to S. 30° E. and dip 40°–55° NE. These faults have produced normal step faulting of small displacement.

The principal developments of 1918 were the driving of a raise southeastward to connect with the old Gold Dust workings and a drift southwestward toward the old Nos. 3, 4, and 5 tunnels on the Golden Wonder and Golden Wonder No. 1. About 53 tons of ore mined on the Gold Dust No. 1 claim was taken from an ore body known as the Pass vein but probably a faulted portion of the main vein. This ore was taken to the mill by pack horses.

The ore from the mine is transported to the mill by aerial tram. The mill is equipped with three batteries containing 13 stamps of 1,000 and 1,050 pounds each, amalgamating plates, classifiers, and a 30-ton cyanide plant. The mill operates three shifts a day and handles 50 tons in 24 hours. The plant is driven by power generated by a Pelton wheel and turbine.

The Willow Creek Mines have taken an option on the Lucky Shot and Panhandle groups now under development and plan to operate these next year.

WAR BABY PROSPECT.

The War Baby prospect consists of four claims, known as the War Baby Nos. 1, 2, 3, and 4, on Craigie Creek at an elevation of about 3,000 feet and 2 miles from the mouth of the creek. The property was located in 1918 and is now being developed by W. S. Horning, C. A. Bartholf, David Miller, and W. T. Rock.

Surface stripping has exposed a mineralized zone about 33 feet across containing four or five parallel quartz veins that strike N. 80° E. and dip 17°–62° NW. The footwall of the lode is altered granite with 9 inches of quartz. Above this through an interval of over 30 feet are three quartz veins from 1 to 5 inches thick cutting quartz diorite. The hanging wall of the lode appears to be a red-stained fissure parallel to the quartz veins and dipping steeply northwest toward the canyon wall. About 600 feet to the southwest what appears to be the same lode is exposed. At this place a lode from 3 to 4 feet thick carries a quartz vein 15 inches thick and stringers of quartz in altered granite.

The ground is being developed by a tunnel which is expected to intersect the vein 100 feet from the mouth. A Straub well equipped with 10 stamps of 250 pounds each is in course of construction. The mill will be run by a gasoline engine and will be used for prospecting the ore and making small mill runs until the output necessitates a mill of greater capacity.

PANHANDLE AND LUCKY SHOT PROSPECTS.

The Panhandle and Lucky Shot groups of claims are being developed just west of the War Baby claims on what appears to be the same vein as the War Baby lode. These two groups of claims are said to cover the outcrops of two parallel veins striking about east and a third vein striking N. 60° W. and crossing the other two. Development work was begun on these claims in 1918, and some surface openings were made preparatory to underground operations. The Willow Creek Mines now have an option on this property and plan to operate it next season.

ALASKA FREE GOLD MINING CO.'S MINE.

The mine of the Alaska Free Gold Mining Co. is on Fishhook Creek at an elevation of about 4,300 feet. It is now operated on a lease to W. P. Martin, who continued development work and milling during a part of the season of 1918. The principal development work has been done on the Skyscraper vein, on which nine tunnels have been driven with an aggregate length of over 2,300 feet, besides connecting winzes and stopes. The ore from the mine is lowered by aerial tramway to the mill, which is equipped with two Chilean mills of 40-ton capacity. The tailings are treated in a cyanide plant.

GOLD CORD MINE.

The Gold Cord mine is on the east side of Craigie Creek near its head, at an elevation of about 4,100 feet. This property was located in 1915, and some development work was done. A mill test on 100 tons of ore made last year is said to have proved satisfactory, and the property was sold to J. H. Smith and Joseph Swan. During 1918 the property was further developed by W. P. Martin under a lease from the owners.

The developments on the Gold Cord at the end of the working season of 1918 consisted of about 500 feet of tunnel, a crosscut, two small stopes, and an open cut on the lode. The lode strikes N. 10° W. and dips 30°–65° SW., with an average dip of about 40°. The ore body differs somewhat from the typical veins of the region. It is a stringer lode composed of reticulating veins of quartz which penetrate the quartz diorite country rock, forming a lode that in places is 13 feet wide. The tunnel is driven along the lode but does not open its entire width except where the lode is narrowed by pinching or faulting or where a crosscut or a stope has been extended. The lode has formed on a prominent joint plane, along which faulting has later taken place and evidently pinched the vein. The hanging wall is well defined. The footwall is less definite and is marked by a number of parallel planes along each of which the ore appears to terminate abruptly.

The quartz diorite included within the quartz veins is altered and mineralized with sulphides, but the gold content has not been determined.

MABEL MINE.

The Mabel mine is on the west side of the valley of Little Susitna River, on a small tributary of Reed Creek. The vein has been exposed on the surface for a claim length by short tunnels and open cuts. The vein strikes about north and dips west at a low angle. The mine is being developed by two parallel tunnels known as tunnels 2 and 3, driven northwestward to intersect the vein. The principal work has been done on tunnel 2, which follows a joint plane. About 20 feet from the mouth the tunnel encountered a fault striking north to northwest and dipping 45°–60° W. A drift extended northward along this fault plane exposed the quartz vein abutting against it. The portion of this vein extending from this fault to the surface has been stoped out and milled for a part of the distance between the two tunnels. At the face of tunnel 2 a short drift was turned off to the north and a much longer one to the south, following the intersection of another fault and quartz vein. Both strike about N. 30° E. and dip northwest. The quartz vein dips 30°, but the fault is much steeper and exposes the quartz vein in the northwest wall of the drift. The quartz here is as a whole of rather low grade but carries stringers of very rich ore.

Tunnel 3 extends northwestward about parallel to tunnel 2. Near the face a flat-lying vein of quartz was cut and followed southward by a drift. The vein is about 4 feet wide but is barren. A crosscut to the east cut a small quartz vein with some very rich pockets. This vein, which also is cut off by a fault, resembles the eastern vein in tunnel 2 in character, but correlations between the veins exposed in the different workings have not been established.

The ore is transported by an aerial tramway to a 15-ton Denver mill operated by water power. The tailings are ponded for future treatment. The Mabel mine and mill were operated in 1918 on a small scale.

TALKEETNA GOLD MINING CO.

The mine and mill of the Talkeetna Gold Mining Co., previously known as the Matanuska Gold Mining Co., were operated during a part of the season of 1918. This property is on the north side of Fairangel Creek, near its head.

ANCHORAGE GOLD MINES CO.

The Pearl, Glacier, and Teddy groups of claims on Archangel Creek near the glacier were taken over by the Anchorage Gold Mines Co., recently organized in Anchorage. The company is represented by Byron Bartholf, president; Sidney Anderson, vice president; A. G. Thompson, secretary; and E. M. Culbertson, treasurer. It is the plan of the company to start active development as soon as weather conditions permit.

LE ROI MINING CO.'S PROPERTY.

The property of the Le Roi Mining Co. is on Good Hope Creek, a tributary of Reed Creek, near the summit of the high divide east of the main creek and about 1¼ miles northeast of the mouth of the creek and 1½ miles east of the Mabel mine. This deposit was discovered in 1917, and since then temporary work has been in progress. A wagon road from the Willow Creek road was built, mining equipment assembled, and underground work started.

WEBFOOT AND RUTLAND PROSPECTS.

Some development work was done by Gaikema & Conroy on the Webfoot and Rutland groups of claims, near the junction of Archangel and Fairangel creeks. The vein on the Webfoot is reported to be exposed by surface stripping for a claim length. Some development work was also done on the Gem prospect in the same locality. On the Fern and Goodell claims a tunnel was driven 300 feet along the lode, and work was continued during the winter.