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GEOLOGY AND COAL RESOURCES OF THE EASTERN PART
OF THE LOWER MATANUSKA VALLEY COAL FIELD, ALASKA

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INTRODUCTION

Location

The lower Matanuska Valley coal field is in south-central Alaska near the head of Cook Inlet, about 60 miles by railroad northeast of Anchorage (fig. 1). It occupies an area roughly 7 miles long and $1\frac{1}{2}$ miles wide that trends northeastward parallel to the front of the Talkeetna Mountains to the north. The eastern part of the field is considered in this report. The western part has recently been described. 1/

The two operating coal mines in the area, the Government-owned Eska mine and the privately owned Evan Jones mine, are served by a 23-mile branch line of the Alaska Railroad. The Glenn Highway, a year-round gravel-surfaced road connecting Anchorage with the Richardson Highway and the interior of Alaska, passes about 2 miles south of the mines.

Previous Investigations

The first detailed study of this area was made in 1934 and 1935 by Tuck, 2/ who made topographic and geologic surveys of most of the area included in this report. Earlier writers 3/ have described the general geology of the region of which this area is a part and have reported periodically on mining developments and described the coal beds encountered. 4/

1/ Payne, T. G., and Hopkins, D. M., Geology and coal resources of the western part of the lower Matanuska Valley coal field, Alaska. U. S. Geol. Survey, 1944. (Mimeographed)

2/ Tuck, Ralph, The Eska Creek coal deposits, Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 880-D, pp. 185-214, 1937.

3/ Paige, Sydney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, 71 pp., 1907.

Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, 98 pp., 1912.

4/ Chapin, Theodore, Mining developments in the Matanuska coal fields, Alaska: U. S. Geol. Survey Bull. 712-E, pp. 152-163, 1920.

_____, Mining developments in the Matanuska coal fields, Alaska: U. S. Geol. Survey Bull. 714-D, pp. 197-199, 1921.

Present Investigation and Acknowledgments

This report is based chiefly on field studies made by the writers between July 20 and October 1, 1944. Prior to that time, since the autumn of 1940, the senior author as geologist for the Alaska Railroad had mapped the underground workings and geology of the Eska mine and had done considerable surface prospecting on coal-leasing unit 7. T. G. Payne and D. M. Hopkins of the Geological Survey mapped the extreme western part of the area shown on the accompanying map (fig. 2) and also measured several of the stratigraphic sections at surface localities and in underground workings that are illustrated in figure 3. Most of the topography shown on figure 2 was taken, with minor revisions, from a previously published map. ^{5/} Strips about a quarter of a mile wide along the north and west margins and the southwest corner of the area were mapped both topographically and geologically by Payne and Hopkins and the writers. Most of the geology shown on figure 2, with the exception of the greater part of the boundaries of areas covered by Eska conglomerate and slide rock, and of faults in abandoned workings, is based on field work of the writers.

A special feature of the field work was the use of a small post-hole type soil auger to locate and trace coal beds and to determine the character of bedrock under several feet of overburden. By this means it was possible not only to expose coal sections at critical localities with a minimum of trenching, but also to trace quickly certain concealed coal beds for considerable distances across areas where the amount of time and labor involved in ordinary pick-and-shovel methods would have been prohibitive.

The managements of both the Eska and Evan Jones mines cooperated fully in furnishing mine maps and access to underground workings. The Alaska Railroad made facilities for room and board at Eska available to Survey personnel at all times. The writers have drawn freely on the results of previous work by Payne and Hopkins and have consulted freely with Mr. Payne during the preparation of this report. G. O. Gates, under whose general supervision this work was done, has given many helpful suggestions both in the field and in the office.

GEOLOGY

General Features

The lower Matanuska Valley coal field lies in an area of moderately

^{5/} Tuck, Ralph, op. cit., pl. 11.



Figure 1. Index map of Alaska showing location of lower Matanuska Valley coal field

deformed Tertiary sediments, ranging from conglomerate to claystone, that is underlain by Upper Cretaceous shale and sandstone, the whole having been depressed between major parallel faults that border the valley and separate the Cretaceous and Tertiary rocks from the older and more highly deformed metamorphic and intrusive rocks that form the mountains on either side.

The Cretaceous and Tertiary rocks are largely concealed by Quaternary glacial and alluvial deposits, which cover all but the steepest slopes with a mantle of boulders, gravel, sand, and silt ranging from a few inches to 50 feet or more in thickness. Considerable areas on the lower slopes of Wishbone Hill are covered with slide rock, which consists mainly of fragments of conglomerate, including blocks as much as 40 feet in diameter, that have resulted from undersapping of the resistant capping of Eska conglomerate by erosion of the softer Chickaloon beds.

The only known igneous rocks in the area are two small diabase dikes. One of these, about 2 miles west of Jonesville, is intruded into the Eska conglomerate, and the other, at locality P on the north slope of Wishbone Hill (fig. 2), cuts across beds, including coal, in the upper part of the Chickaloon formation.

Stratigraphy

The Tertiary rocks of the lower Matanuska Valley were described by Martin and Katz ^{6/} as including three non-marine sedimentary formations--the Chickaloon formation, the Eska conglomerate, and an unnamed assemblage of arkose, conglomerate, and shale. The Chickaloon formation comprises at least 5,000 feet of claystone, siltstone, and sandstone, and includes several groups of coal beds in the upper part. The Eska conglomerate, with a minimum thickness of 1,700 feet, overlies the Chickaloon formation and appears to be conformable with it in the lower Matanuska Valley ^{7/}, although an unconformable relationship has been ascribed to the same formations in the upper Matanuska

^{6/} Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, pp. 39-54, 1912.

^{7/} Martin, G. C., and Katz, F. J. op. cit. p. 54.

Tuck, Ralph, op. cit., p. 195.

Payne, T. G., and Hopkins, D. M., op. cit., p. 3.

Valley 8/. The unnamed Tertiary formation is not exposed in the area discussed in this report.

Chickaloon formation - The Chickaloon formation, as exposed at the eastern end of Wishbone Hill and along the middle fork of Eska Creek north of the mapped area, comprises at least 5,000 feet of claystone, siltstone, sandstone, a few thin beds of fine-grained conglomerate, and coal. The coal is mostly in the upper 1,400 feet of strata. The only known exceptions are two coaly zones in the lower 500 feet as exposed near the headwaters of Eska Creek; one of these zones includes a $3\frac{1}{2}$ -foot bed of clean coal. The coal in the upper part of the formation occurs in several more or less well-defined groups of three or more beds separated by comparatively thick intervals of strata with little or no coal. Ironstone, in thin layers and nodular zones, or in irregularly distributed concretions or masses ranging from a few inches to several feet in diameter, is a widespread component of all the strata, including the coal. Petrified wood occurs locally, particularly in or associated with the Eska and Chapin coal beds. Fossil-leaf impressions are common, particularly in the roof rock of the coal seams.

The part of the formation below the coal-bearing section consists predominantly of dark purplish gray claystone and silty claystone and minor interbedded siltstone and sandstone. Locally the sandstone grades into fine-grained conglomerate. This part of the section is best exposed along the middle fork of Eska Creek, where successively lower beds of the southward-dipping sequence are exposed upstream to the contact with the underlying Cretaceous (?) formation. Strata believed also to represent the basal beds of the Chickaloon formation are exposed on the south slope of a low ridge $1\frac{1}{2}$ miles northeast of Eska. The section at that locality includes several coal beds, which are described in a later section of this report.

The upper or coal-bearing part of the Chickaloon formation consists of 900 to 1,400 feet of light-gray to buff sandstone, siltstone, claystone, and coal. All textural gradations from coarse sandstone to fine claystone are present and the rocks commonly grade into one another both along and across the beds. The coaly claystone of the upper part of the formation is in general of lighter color than that of the lower part and commonly includes a few thin coal streaks and irregular fragments of carbonaceous matter. Locally, by increase in proportion of coaly material, claystone passes into coaly claystone and thence into coal.

8/ Capps, S. R. Geology of the upper Matanuska Valley, Alaska, U. S. Geol. Survey Bull. 791, p. 42, 1927.

Certain thin layers of claystone or clay are exceptionally persistent over considerable areas and were of value in the correlation of associated coal beds. The best known and most persistent layer is the so-called "Eska marker", which lies just below the hanging wall of the Eska coal bed. This horizon is marked by at least one, and at many points two, thin light-colored clay bands that stand out sharply from the enclosing rock. The Eska marker is present throughout both the old and new workings at the Eska mine and was noted as far west as locality V (fig. 2), and thus has a known extent of nearly $1\frac{1}{2}$ miles. A second distinctive claystone band was traced between localities O and U, on the north side of Wishbone Hill, for a total distance of 3,000 feet. This band, consisting of one or more feet of light-gray claystone that weathers to an orange-yellow sticky clay, was found in several exposures a few inches above one of the lower coal beds of the Premier group and was useful in helping to identify that bed at the different localities. This claystone band, together with several other light-colored clay beds exposed in the Evan Jones crosscut tunnel and one in the new Eska tunnel, in many ways resembles bentonite, a decomposed volcanic ash. It appears to swell greatly on exposure to air and moisture and becomes soft and plastic, so that it oozes out of the enclosing strata in underground exposures. One or more less persistent claystone partings are common in certain other coal beds in the area.

The Chickaloon formation is characterized by lateral changes both in character and thickness of the strata. Thus the Eska bed, one of the principal coal beds in the Eska mine, includes as much as 6 feet of coal in places in the south-limb workings but thins to little more than 2 feet at the west end of the north-limb workings (fig. 2). As another example, a medium-to-coarse-grained feldspathic sandstone that overlies the Eska bed is 75 feet thick in the bluff just west of Eska Creek, nearly 90 feet thick in the Eska crosscut tunnel, and is entirely lacking in the Evan Jones tunnel only $\frac{3}{4}$ mile to the west, where the corresponding stratigraphic interval is occupied by fine-grained siltstone. Similar differences in thickness characterize not only individual beds but groups of beds. For example, the overall thickness of the coal-bearing part of the Chickaloon formation decreases from 1,400 feet in the Eska mine to about 900 feet at the western edge of the area mapped. Most of this thinning is in the part of the section between beds 5 and 8 of the Evan Jones mine. This interval thins from about 500 feet at the crosscut tunnel to less than 200 feet at locality Q, less than a mile to the west (figs. 2 and 3).

Although in each of the examples cited the thinning was in a westerly direction this is not always the rule, at least as applied to individual coal beds. Bed 5 of the Evan Jones mine thickens from less than 10 feet at the crosscut tunnel to 22 feet at chute 23, about

1,500 feet to the west. This, however, may be an exceptional case of only local significance, as the same bed where exposed still farther west in surface outcrops is about 10 feet thick.

The examples cited above emphasizes the importance of relying on sequence of rock types, rather than on thickness of strata, in attempting to correlate coal beds in deposits of this type.

Eska conglomerate. - The Eska conglomerate is composed dominantly of pebbles, cobbles, and boulders in a sandy matrix, but includes numerous sandstone beds ranging from a few inches to 40 feet or more in thickness. The formation is divided into two parts on the basis of the composition and size of the coarser constituents. The lower part, about 1,100 feet thick, is characterized by pebbles and cobbles that are composed dominantly of volcanic and metamorphic rocks, chert, vein quartz, and jasper and include very little granite. The upper part, at least 600 feet thick, consists of boulders and cobbles mostly of coarse-grained granite and diorite ^{9/}. Further study may result in further subdivision based on pebble composition. This should prove useful in determining the approximate location of the base of the conglomerate at points where the underlying coal-bearing formation is completely concealed by surficial deposits, as along the base of Wishbone Hill southwest of Jonesville.

Structure

The dominant structural feature of the eastern part of the lower Matanuska Valley coal field is the southwest-plunging Wishbone Hill syncline, which has been cut into a series of displaced segments and otherwise deformed by several major northeast-trending transverse tear faults and by many minor faults and shear zones (fig. 2). The structure of this area has had a strong influence on mining operations. As the most readily available coal is on the moderately dipping limbs of the syncline, practically all mining to date has been done by room-and-pillar method in which chutes convey the coal to the gangways.

Dips of the coal beds as revealed in mine workings range for the most part from 30° to 40°, although dips as low as 12° and as high as 55° were encountered in the Eska mine, along the synclinal axis and on the south limb, respectively. In general the dip is progressively steeper westward. Thus the dips on the north limb in the Eska mine range in general from 25° to 30° east of the Eska fault zone, and from 35° to 40° west of the fault zone; and in the Evan Jones mine from 31° near the crosscut tunnel to 38° at the west end of the workings on bed 8. On the south limb in the Eska mine, dips range generally from less than 25° east of the crosscut tunnel to more than 50° at the southwest end of the workings. An exception to the

^{9/} Payne, T. G., and Hopkins, D. M., op. cit., p. 3.

general rule occurs on the south limb in the Evan Jones mine, where old mine maps show dips of 30° east of the tunnel and dips as low as 18° on the same beds west of the tunnel. The flatter dips west of the tunnel may be in part the result of drag along the adjacent Jonesville fault, but probably in larger part reflect a change in the shape of the syncline, which broadens markedly west of the Evan Jones mine (fig. 4, sections C-C'-C" and D-D'-D").

The major faults of the area have constituted definite barriers to further mining wherever encountered underground, with the single exception of the Eska fault in the old north-limb workings of the Eska mine. This is apparent from noting the relation of gangway faces to the principal faults as shown in figure 2. The minor faults and shear zones in general do not prevent mining of the coal, but they do greatly increase the labor and cost of mining and impair the quality of the product. Many of the smaller faults and shear zones that were encountered underground are not shown on fig. 2.

The easternmost major fault, referred to by Tuck as the "north-east fault" ^{10/} apparently differs from most of the faults farther west in that it appears to be a normal fault in which the east side was dropped vertically 350 to 400 feet ^{11/}, whereas the Eska and Jonesville faults and most of the associated smaller faults are tear faults in which the principal component of the displacement was horizontal.

The Eska fault described by earlier writers is the southeastern boundary of a highly sheared zone several hundred feet wide that is bounded on the northwest by a second strong tear fault (fig. 2). The strata between the two major faults, as exposed in the new Eska tunnel, are cut by numerous smaller faults and shear zones and deformed by several minor irregular folds. This zone is herein called the Eska fault zone. Little is known of the displacement along each of the two major faults, largely because of the extreme structural complexity in the intervening strata. It is possible, however, to draw fairly definite conclusions as to the relative displacement of the blocks on either side of the fault zone. The northwest block moved southwestward and downward with respect to the southeast block. Although the amount of displacement can be determined with considerably less reliability than its direction, the horizontal and vertical components of the displacement apparently were of the order of 1,000 feet and 400 feet, respectively.

^{10/} Tuck, Ralph, op. cit., p. 198.

^{11/} Chapin, Theodore, Mining developments in the Matanuska coal fields, Alaska: U. S. Geol. Survey Bull. 712-E, p. 162, 1920.

The Jonesville fault (fig. 2) appears to have resulted from a movement in which the northwest side moved about 400 feet horizontally southwest. No direct evidence of the relative direction and amount of vertical movement is available, but it is believed to have been small. The Jonesville fault, like the Eska fault zone, is a zone of shearing rather than a single fracture. Although the southeast boundary of the fault zone is concealed by timbers in the Evan Jones tunnel, the maximum width of the more intensely disturbed zone is probably not more than 200 feet.

Most of the minor faults exposed in the Eska and Evan Jones mines, especially those nearest the Eska and Jonesville faults, accord closely both in strike and in relative direction of displacement with the major faults. The exceptions to this rule are in general smaller faults, many of which are probably the result of local stresses developed within the blocks between the larger faults. A few of the minor faults appear to be thrust faults, indicating compression, but even these may be related to the shearing stresses that caused the larger tear faults.

The dip of the major faults is generally close to vertical and is rarely less than 65° . The smaller faults range in dip from 25° to vertical, but the steeper dips are more common. All faults are characterized by rather abrupt and irregular changes in both strike and dip, so that it is impossible to project the position of a fault into unexplored ground with certainty.

The study of faults in this area has yielded considerable information on the position and plunge of the axis of the Wishbone Hill syncline between the Eska and Evan Jones mines. Tuck 12/, stated that the plunge in places is as much as 25° but averages about 10° , and showed the approximate position of the axis on his geologic map. He suggested that "many of the sharp curves may be offsets due to faulting", and later work has borne out this suggestion (fig. 2). Recent development work at the Eska mine has shown that the axis near the new Eska tunnel is about 400 feet farther northwest than shown on Tuck's map, and has also shown that the Eska fault extends southwestward across the axis and the south limb of the syncline. The plunge of the axis where crossed by the Eska mine workings is less than 15° , and the approximate parallelism of the opposite limbs between the new Eska and Evan Jones tunnels indicates that the synclinal axis in this interval must be nearly flat. The relatively lower position of the coal-bearing sequence in the Evan Jones mine, which apparently led Tuck to infer a plunge of as much as 25° , is believed to be the result of downthrow along the Eska fault zone. West from the Evan Jones tunnel, however, a general westward plunge of 5° to 10° is indicated by the fact that successively higher zones of Eska conglomerate swing across the axis.

12/ Tuck, Ralph, op. cit., p. 196 and pl. 11.

COAL DEPOSITS

General Character and Distribution

The coals of the lower Matanuska Valley are high-volatile bituminous coals and are non-coking. The coal has a well-developed cleat in two directions approximately at right angles to each other and perpendicular to the bedding, which causes it to shatter readily to small sizes. The ash content ranges from 10 to 25 percent, but because of slabby roofs and numerous clay partings the ash in the mine product may run as high as 40 percent. The coal rarely breaks free from the included partings or the bony footwall, so that both crushing and washing are essential steps in the preparation of a satisfactory shipping coal.

Representative analyses of the coals are given in table 1. The analyses are arranged in the order of stratigraphic sequence and represent a stratigraphic range of about 850 feet. There is no appreciable change in fuel ratio (ratio of volatile matter to fixed carbon), the principal differences being in the percentage of ash.

The coal beds are in several more or less distinct groups, which are designated as follows, from oldest to youngest: Little Eska, Eska, Maitland, Premier, and Jonesville groups. The extent and stratigraphic relations of these groups of coal beds are shown in figures 2 and 3. The letters used on these illustrations to designate the localities at which stratigraphic sections were measured are an eastward continuation of the letter series used by Payne and Hopkins in the western part of the field.

The Little Eska group, named for its local resemblance on a smaller scale to the overlying Eska group, is exposed in the new Eska tunnel near the portal and was traced along the north slope of Wishbone Hill as far west as locality T (figs. 2 and 3). None of the coal beds of this group are considered minable under present conditions. The Eska group includes the Eska, Shaw, and Martin beds, which have been mined on both sides of Eska Creek in the old Eska mine workings and on the west side in the new workings. This group was traced westward to locality P, but west of the Evan Jones tunnel it consists only of a carbonaceous zone including several coal layers too thin to be of economic importance (fig. 3). The Maitland group includes the Maitland, David, and Emery beds, all of which were mined in the old Eska workings on both sides of Eska Creek. The Chapin, Maitland, David, and Emery beds have been correlated with beds 7, 7A, 7B, and 8, respectively, in the Evan Jones mine, which in turn continue westward, probably beyond the area mapped.

The Premier group, which was traced eastward from the Moose Creek area to locality P, by Payne and Hopkins in 1943, has been

Table 1. — Analyses of coal from the eastern part of the lower Matamuska Valley coal field, Alaska

Coal bed	Location	Form of analysis 1/	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	B.t.u. per pound
Bed 4 2/	South-limb workings, Evan Jones mine	A	4.39	38.40	40.72	16.09	0.27	11,298
		B	2.61	39.52	41.48	16.39	.27	11,509
		C	—	40.58	42.59	16.83	.28	11,817
		D	—	48.79	51.21	—	.34	14,207
Bed 3 2/	South-limb workings, Evan Jones mine	A	3.5	37.3	40.2	19.0	.3	10,990
		B	2.3	37.8	40.7	19.2	.3	11,120
		C	—	38.7	41.6	19.7	.3	11,380
		D	—	48.2	51.8	—	—	14,170
Bed 5 2/	North-limb workings, Evan Jones mine	A	3.5	36.8	38.4	21.3	.2	10,450
		B	2.3	37.2	39.0	21.5	.3	10,580
		C	—	38.1	39.8	22.1	.3	10,830
		D	—	48.9	51.1	—	.3	13,900
Bed 6 2/	North-limb workings,	A	3.8	37.9	43.3	15.0	.3	11,540
		B	2.4	38.4	44.0	15.2	.3	11,710
		C	—	39.4	45.0	15.6	.3	12,000
		D	—	46.6	53.4	—	.3	14,220
Bed 8 3/	North-limb workings, Evan Jones mine	A	4.9	36.1	45.9	13.1	.3	11,830
		B	—	37.9	48.4	13.7	.3	12,450
		D	—	44.0	56.0	—	.4	14,430
Upper Shaw 3/	South-limb workings, Eksa mine	A	3.7	41.0	44.4	10.9	.5	12,410
		B	—	42.6	46.1	11.3	.5	12,890
		D	—	48.0	52.0	—	.6	14,540

1/ A, as received; B, air dried; C, moisture free; D, moisture and ash free.

2/ From U. S. Geological Survey Bull. 880-D, p. 202.

3/ From U. S. Bureau of Mines Tech. Paper 668, p. 5.

correlated with beds 5, 6, 7, 7A and 7B of the Evan Jones mine. Beds 7A and 7B are therefore common to the Maitland and Premier groups. The Jonesville group, which includes the uppermost coal beds in the Chickaloon formation, was first exposed in the old south-limb workings of the Evan Jones mine. It is represented by at least two of the three principal beds as far west as locality N, and is believed to be continuous into the western part of the field, where it was noted and described at several localities by Payne and Hopkins 13/.

In addition to the groups of coal beds just described, a single bed, consisting of two thin benches of coal, bed 9 of the Evan Jones mine, was traced more or less continuously from the west bank of Eska Creek to locality P. Also, several thin coal seams and coaly zones, apparently of only local occurrence, are exposed a few feet beneath the Eska group in the new Eska and Evan Jones crosscut tunnels (fig. 3).

Description and Correlation of Coal Beds

Detailed sections of certain coal beds are shown in figure 5. The sections illustrated have been selected as being most pertinent to future mining developments. The following detailed descriptions are confined to coal beds believed likely to be of principal economic importance in the near future.

Martin bed. - Throughout the Eska mine workings, the Martin bed consists of two benches of clean coal generally $1\frac{1}{2}$ to 2 feet in thickness separated by $\frac{1}{2}$ to 2 feet of coaly claystone. Other thinner beds of coal and bone are commonly present in both the roof and foot-wall (fig. 5, section 3), and a bed of coal a foot or two below the lower bench locally approaches and even exceeds that bench in thickness, but has never been mined. Both the main benches and the parting between them change abruptly in thickness from place to place, so that the bed as a whole within short distances ranges from a minable coal bed with a relatively thin parting to two thin coal beds scarcely worth mining.

The Martin bed at Eska has been correlated with a bed that lies about 20 feet below bed 10 in the Evan Jones crosscut tunnel. This bed has three benches, of which the upper $2\frac{1}{2}$ -foot bench consists largely of clean coal, but the two lower somewhat thinner benches are

13/ Payne, T. G., and Hopkins, D. M., op. cit., pp. 13, 15, 16, and 19.

bony coal (fig. 5, section 2). The correlation of bed 10, and the immediately overlying and underlying coal beds, with the Eska group is based not only on the general similarity of the individual beds and of the group as a whole in the Eska and Jonesville areas, but also on a comparison of complete stratigraphic sections in the two areas (fig. 3, sections at X (Evan Jones tunnel) and Z).

West of the Evan Jones tunnel the Martin bed was completely exposed only at localities T and U. At both localities the upper bench of the Martin includes less than 2 feet of coal and the lower bench consists of bone and a few thin coal seams (fig. 5, section 1). West of locality T the only exposure of the Martin bed is at locality P, where the bed is probably represented by one or more coaly layers, including a bed of clean coal 1-3/4 feet thick.

Shaw bed (bed 10). -- The Shaw bed in the Eska mine consists of two benches of coal, separated by 1 1/2 to 4 feet of coaly claystone and bone, that are known locally as the upper and lower Shaw (fig. 5, section 6). The upper Shaw coal ranges from 2 1/2 to 4 feet in thickness and commonly includes one to three hard claystone markers an inch or less in thickness. This coal has been mined on both limbs of the syncline as well as in the old east-side workings. The lower Shaw coal has an over-all thickness ranging from 3 to nearly 5 feet, but includes as many as 5 claystone partings 1 to 2 inches thick. This coal has been systematically mined only on the north limb for a short distance on each side of Eska Creek. To the west and on the south limb it has not been mined, largely because it is too close to the upper Shaw bed to be mined separately and because the amount of rock in the lower Shaw partings and in the thick parting between the two benches made the mining of both benches together undesirable. West of the present Eska workings the main parting may be thin enough and the lower bench clean enough to encourage the mining of the entire bed, particularly now that a washer has been installed at Eska.

Bed 10, the equivalent of the Shaw bed in the Evan Jones cross-cut tunnel, consists of two benches, each about 2 1/2 feet thick, separated by about 1 foot of coaly claystone (fig. 5, section 5). The upper bench is clean coal with a single siliceous claystone parting about 1 inch thick. The lower bench includes only 1 foot of clean coal, the upper and lower parts being bony. This coal has been opened only by a short gangway in the Evan Jones mine, but the two benches may eventually be mined as a single bed.

At locality U, the Shaw bed includes two benches of clean coal 14 to 18 inches thick separated by more than 2 feet of coaly claystone (fig. 5, section 4). A similar section is exposed at locality T, but farther west both benches gradually thin and the number and thickness of claystone partings increase.

Eska bed. -- As typically exposed in the Eska mine workings, the Eska bed consists of a single seam of coal ranging in thickness from 3 to 4 feet, of which the lower 1 to 2 feet is bony and the upper part is relatively clean coal with no persistent claystone partings (fig. 5, section 9). Locally this bed attains an over-all thickness of 7 feet, but unfortunately the added thickness consists chiefly of bony coal. The bed is thickest on the south limb and thinnest at the west end of the north-limb workings, where it is little more than 2 feet thick.

In the Evan Jones tunnel the equivalent of the Eska bed consists of $2\frac{1}{2}$ feet of bony coal (fig. 5, section 8), and at locality U the bed includes about 10 inches of coal that grades downward through bone into coaly claystone (fig. 5, section 7). Between localities Q and U it includes 12 to 18 inches of coal underlain by bone, but at locality P, it is represented by a 10-inch seam of bony coal.

Emery bed (bed 8). -- The Emery bed (bed 8) extends, with exceptionally little variation in character and thickness, from the east side of Eska Creek westward to locality O, and probably extends farther west into the Moose Creek area. On the west side of Eska Creek it has an over-all thickness of $7\frac{1}{2}$ feet, of which $5\frac{1}{2}$ feet is clean coal and the balance is coaly claystone, ironstone, and bone distributed through several partings 1 to 12 inches thick. In the new Eska tunnel the Emery bed has a thickness of only $3\frac{1}{2}$ feet, of which nearly half is bone, but a part of the bed is believed to have been cut out by a strike fault. The Emery bed was traced on the surface from the Eska fault zone almost to the Jonesville fault (fig. 2) by means of auger borings, but no measurements of its thickness were obtained in this interval. Just east of the Jonesville fault two trench exposures measured by Tuck ^{14/} show between 5 and 6 feet of coal including several thin claystone partings. In the Evan Jones tunnel, bed 8 has a total thickness of 5 feet, including two thin claystone markers in the upper part. At the west end of the Evan Jones workings, at locality S, a total thickness of a little more than 4 feet includes 3 feet of coal (fig. 5, section 11). Thicknesses of $4\frac{1}{2}$, 3, and $3\frac{1}{2}$ feet were measured at localities Q, P, and O, respectively. The section at O includes 2 thin claystone partings (fig. 5, section 10).

David bed (bed 7B). -- The David bed (bed 7B), which was mined to a small extent on both sides of Eska Creek, has been traced westward as far as locality V, and may be represented by coal in the lower part of the section at locality O. From a maximum thickness of 3 feet of clean coal, in a surface exposure on the west bank of Eska

^{14/} Tuck, Ralph, op. cit., pl. 13, sections 42 and 43.

Creek, it decreases to about 2 feet in a trench exposure ^{15/} on the north limb just east of the Jonesville fault (fig. 2). The David bed may not extend down to the level of the Eska crosscut tunnel, although it may be represented by the coaly material in highly faulted rocks exposed in the tunnel a short distance north-west of the Emery bed.

In the Evan Jones tunnel, bed 7B consists of two benches. The upper bench, including 2 feet of clean coal with a thin claystone marker, is separated by $2\frac{1}{2}$ feet of bone and coaly claystone from the lower bench, which contains about 2 feet of somewhat bony coal. At locality V this bed is probably represented by a $2\frac{1}{2}$ -foot seam of clean coal that includes a thin band of coaly ironstone. Bed 7B cannot be correlated with certainty with coal exposures farther west, but it may be represented by coal seams that lie about 25 feet above bed 8 at localities O, P, and Q. At these three localities a lower bench, containing $2\frac{1}{2}$ to 3 feet of clean coal, is separated by 3 to 6 feet of claystone from an upper bench 1 to $1\frac{1}{2}$ feet thick.

Maitland bed (bed 7A). -- The Maitland bed (bed 7A) was traced from Eska Creek westward to the Evan Jones crosscut tunnel, and may be represented by coal seams in the upper part of the sections measured at localities V and W. At a surface exposure on the west bank of Eska Creek this bed consists of an upper bench containing 3 feet of clean coal, a $6\frac{1}{2}$ -foot parting of coaly claystone and bone, and a lower bench containing $3\frac{1}{2}$ feet of coal with a few coaly ironstone concretions. The Maitland bed was not identified in the new Eska tunnel, being either cut out by faulting or too high to have been intersected by the tunnel, but it was traced at the surface on the north limb from the Eska fault zone nearly to the Jonesville fault. In a trench east of the Jonesville fault the bed consists of upper and lower benches, $2\frac{1}{2}$ and 2 feet thick, respectively, separated by 6 feet of coaly claystone ^{16/}. In the Evan Jones tunnel bed 7A has an over-all thickness of $8\frac{1}{2}$ feet but includes only 2 feet of clean coal, mainly in a single bench near the base. Possible equivalents of bed 7A at localities V and W contain at least $3\frac{1}{2}$ feet of clean coal. The exact relation of bed 7A to coal exposed farther west is not known, but it is possible that beds 7 and 7A are splits of a thick coal seam exposed at localities O and Q that has been correlated with bed 2 of the Buffalo mine in the Moose Creek area (fig. 3 and fig. 5, sections 12 and 18).

^{15/} Tuck, Ralph, op. cit., pl. 13, section 39.

^{16/} Tuck, Ralph, op. cit., pl. 13, section 37.

Chapin bed (bed 7). — The Chapin bed (bed 7) is exposed on both sides of Eska Creek and was mined to a small extent on the east side. According to Tuck 17/, this bed as exposed east of Eska Creek consists of an upper bench of coal at least 2 feet thick (the top was not exposed), a $2\frac{1}{2}$ -foot coaly claystone parting, and a lower bench containing nearly 3 feet of coal. This bed was exposed in a trench on the north limb a short distance west of the Eska fault zone (fig. 2), where a 10-foot section includes 9 feet of relatively clean coal in two benches separated by a 1-foot claystone parting. Farther west, in a trench just east of the Jonesville fault, the bed consists of two benches of coal more than 3 feet thick separated by 5 feet of coaly claystone 18/. Bed 7 in the Evan Jones tunnel consists of an upper 1-foot bench of coal, a 3-foot parting of claystone and bone, and a lower 3-foot bench of coal that is bony near both roof and footwall and includes a prominent siliceous claystone marker. The possibility that bed 7 may be correlative with coal exposed at localities O and Q was suggested in the discussion of bed 7A.

Bed 6. -- A coal bed corresponding closely in stratigraphic position to bed 6 of the Evan Jones mine was exposed in a trench on the north limb just west of the Eska fault zone (fig. 2). The bed consists of upper and lower benches of clean coal, 2 feet 4 inches and 3 feet 10 inches in thickness, respectively, separated by 1 foot of thin-bedded claystone and coal. In the Evan Jones tunnel, bed 6 consists of an upper $2\frac{1}{2}$ -foot bench of coal, a 2-foot claystone parting, and a lower bench of coal with an over-all thickness of $5\frac{1}{2}$ feet including three claystone and ironstone partings 3 to 5 inches thick. A somewhat similar section is exposed 1,800 feet west in a crosscut just west of chute 32 on bed 5 (fig. 5, section 14). Bed 6 is believed to be represented by a 7-foot bed including 6 feet of coal at locality Q (fig. 5, section 13), and probably also by coal exposed at localities O and P, but poor exposures and disturbed condition of the coal precluded definite correlation at those points.

Bed 6 may possibly be represented on the south limb of the Wishbone Hill syncline by bed 00, exposed in the Evan Jones tunnel near the portal.

Bed 5. -- A coal bed believed to be equivalent to bed 5 of the Evan Jones mine was partly exposed in a trench on the north limb a short distance west of the Eska fault zone (fig. 2). There a coaly

17/ Tuck, Ralph, op. cit., pl. 13, section 28.

18/ Tuck, Ralph, op. cit., pl. 13, section 35.

section of nearly 17 feet included an upper 1-foot bench of coal with ironstone nodules underlain by 4 feet of coaly claystone and some coal, a middle bench with 4 feet of clean coal underlain by 1 foot 8 inches of coaly claystone, and a lower bench including at least 6 feet of coal with ironstone nodules. The footwall of the lower coal was not exposed. In the Evan Jones crosscut tunnel bed 5 has an over-all thickness of 9 feet but is very dirty, including less than 4 feet of clean coal distributed through several thin benches. At chute 23 the bed has an over-all thickness of more than 20 feet, including an upper 14-foot bench of coal, partly bony, with a few thin claystone partings, separated by 4 feet of coaly claystone from a lower bench of clean coal at least 3 feet thick. Near chute 32, bed 5, with a total thickness of more than 20 feet, includes two benches of relatively clean coal, 4 and 7 feet thick, each of which includes several thin claystone partings (fig. 5, section 17).

Bed 5 is well exposed at localities O, Q, and U, and at all three localities it includes at least 4 feet of clean coal and a considerable additional thickness of bony coal and bone (fig. 5, sections 15, 16, and 18). The correlation of the upper coal bed at these three localities with bed 5 in the Evan Jones workings to the east is based on the facts that in both areas, (1) the bed is the upper member of a distinctive group of coal beds, (2) the bed is closely overlain by a compact, ridge-forming siltstone bed which was traced almost continuously between the two areas, and (3) the siltstone is in turn overlain by a thick sequence of barren sediments.

Bed 5 may be the north-limb equivalent of bed O, or possibly of both beds O and OO, of the south limb. This tentative correlation is predicated on the correlation of a group of beds that overlie bed 5 on the north limb with beds 1 to 4 on the south limb.

Bed 2. -- Coal beds exposed in the $W\frac{1}{2}SE\frac{1}{4}NW\frac{1}{4}$ sec. 16, (fig. 2) and presumably lying within the Eska fault zone, are believed to include beds 2, 3, and 4 of the Jonesville group. The supposed equivalent of bed 2 at this locality comprises two benches of coal, 2 and 3 feet thick, separated by 2 feet of claystone (fig. 5, section 21). At locality X, a $3\frac{1}{2}$ -foot bed of coal with several thin claystone partings, underlain by 2 feet of bone (fig. 5, section 20) is believed to represent bed 2. The correlation of this bed, and associated coal beds and coaly zones, with beds 1 to 4 in the south-limb workings of the Evan Jones mine, is based on general similarity in stratigraphic sequence, and on the fact that the coal beds of both localities are about the same distance below the Eska conglomerate. A coal bed, tentatively correlated with bed 2, is exposed at locality O, where it includes 4 feet of coal and some bone, and at locality N, where it consists of $5\frac{1}{2}$ feet of coal and bone interspersed with several thin claystone partings (fig. 5, section 19).

Bed 3. -- The probable equivalent of bed 3 in the $W\frac{1}{2}SE\frac{1}{4}NW\frac{1}{4}$ sec. 16 includes nearly 4 feet of clean coal overlain and underlain by coaly claystone and a few thin coal beds (fig. 5, section 21). At

locality X a 12-foot coal bed with several claystone partings ranging from 1 inch to 1 foot in thickness (fig. 5, section 20) is believed to represent bed 3. An 8-foot section at locality P, consisting of coal with 3 claystone partings 2 to 5 inches thick, probably represents bed 3, but neither footwall nor hanging wall was exposed. The upper part of the coal section at locality O, including at least 5 feet of coal and two 6-inch claystone partings, is thought to represent the lower part of bed 3. A complete section of bed 3 is exposed at locality N, where it includes three benches of clean coal 2 to $3\frac{1}{2}$ feet thick separated by bone (fig. 5, section 19).

Bed 4. — Bed 4, the uppermost coal bed in the lower Matanuska Valley field, is believed to be represented at least in part by the upper coaly section in the $W\frac{1}{2}SE\frac{1}{4}NW\frac{1}{4}$ sec. 16, where $8\frac{1}{2}$ feet of coal is included in 11 feet of strata (fig. 5, section 22). At locality X this coal was detected only in an auger hole, and its thickness was not determined. Bed 4 in the south-limb workings of the Evan Jones mine is reported to have been less than 4 feet thick. Any coal at this horizon on the north limb west of locality X is deeply buried by overburden, but it is possible that the bed extends westward as far as the other members of the Jonesville group.

Coal Deposits $1\frac{1}{2}$ Miles Northeast of Eska

Coal beds possibly of significant extent and thickness are exposed on the south slope of a low ridge about $1\frac{1}{2}$ miles northeast of Eska, in a deep gully along a southwest-flowing tributary of Eska Creek. These coal beds were traced for 2,400 feet along the west wall of the gully (fig. 6), and detailed sections were measured at several localities (fig. 7).

The strata enclosing these coal beds are typical Chickaloon sediments, consisting dominantly of claystone, which locally grades into siltstone and includes occasional thin beds of fine sandstone. Below the coal-bearing section, however, the proportion of coarser sediments is higher, and in the lower part of the gully medium- to coarse-grained sandstone is the predominant rock. A small diabase dike has been intruded into the sandstone about 1,200 feet south of locality 4 (fig. 6).

The presence of Cretaceous (?) rocks a short distance east of the gully in which coal-bearing rocks are exposed suggests that the coal lies near the base of the Chickaloon formation. This suggestion is supported by the presence in the lower part of the section exposed in the gully of a bed of claystone conglomerate, consisting of flat but well-rounded pebbles of greenish-gray claystone imbedded in a matrix of similar but somewhat softer claystone. This rock is identical in appearance with a bed exposed a short distance above the Cretaceous (?) contact on the middle fork of Eska Creek, the only other locality at which such a

rock was observed.

The structure of the coal-bearing strata in this area appears to be complex, but is not yet known in detail. The attitude of the rocks at some points suggests minor folding and at others indicates strong folding and faulting. The strata in the area as a whole, at least on the west side of the gully, appear to have a general northwest strike and a southwest dip of 20° to 30° .

The sections at localities 1 and 4 show a definite thickening of the coal zone to the south (fig. 7). It is not certain that the coal at locality 2 is the same as that at localities 1 and 4, as it is on the opposite side of the gully and is largely burned, but a projection of dips indicated that it is at about the same horizon. A coal bed that apparently lies about 50 feet stratigraphically below the principal coal zone is exposed at locality 3 (figs 6 and 7) but was not found at any other point in the gully.

The possible economic importance of the coal in this area depends of course on the extent and average thickness of the coal beds, which can be determined only by underground exploration. Any development would be greatly simplified if the coal could be traced southwestward and down the dip to the foot of the ridge in which the gully is cut, whence transportation to the railroad at Eska would be relatively easy.

COAL RESERVES AND FUTURE MINING OPERATIONS

In the following discussion of coal reserves and future mining development, the eastern part of the lower Matanuska Valley coal field is divided into blocks separated by the major faults.

With regard to coal reserves in the block east of the Northeast fault (fig. 2), Tuck ^{19/} stated that the amount of coal above the creek level is small, but suggested that some coal might be developed on both limbs by sinking slopes. Maps, coal sections, and churn-drill logs indicate that possibly as much as 4 million tons of coal lie below the old mine workings. This estimate is based upon the assumption that the synclinal axis east of Eska Creek has a southwest plunge of not more than 10° , and that all the beds of the Maitland and Eska groups continue to the bedrock surface with undiminished thickness and quality and without major interruptions by faulting. The amount of recoverable coal is probably considerably less than the above estimate because of faulting, proximity to the bedrock surface, and the fact that much of the coal lies close to and beneath Eska Creek. Most of this coal, except that of the Eska group on the south limb in the vicinity of Eska Creek, dips less than 20° and could be mined only by a low-pitch method. Further exploration by deeper drilling might

^{19/} Tuck, Ralph, The Eska Creek coal deposits, Matanuska Valley, Alaska; U. S. Geol. Survey Bull. 880-D, p. 210, 1937.

reveal conditions that would warrant further attempts to mine this block, particularly at some future time when the more readily available coal in other parts of the area is exhausted.

In the block between the Eska and Northeast faults, beds of the Eska group have been mined above the 1,000-foot level on both limbs, and above the 800-foot level chiefly on the south limb. Mining from the lower level is still in progress. In addition to the remaining coal available from the active workings and under the present system of mining, a considerable tonnage of coal in the Eska group lies along the synclinal axis east of the active workings. This coal, with dips ranging from 12° to 25° , could be mined only by a low-pitch method. An additional tonnage extends down the dip from the 800-foot level along the axis and both limbs of the plunging syncline to the Eska fault. Much of this coal also would have to be mined by a low-pitch method.

The position of the Emery bed in the Eska crosscut tunnel indicates that the Maitland group and possibly one or two higher coal beds underlie a relatively small area along the axis in the western part of this block. None of the beds above the Emery, with the possible exception of the David bed, is believed to extend down to the tunnel level. Their extraction therefore, would require some special method of development, including a raise or incline to a higher level. Insufficient data are available on which to base an estimate of the tonnage in the Maitland group and higher coals in this block, but the total does not exceed a few hundred thousand tons.

The Eska fault zone is believed to contain no minable bodies of coal on the north limb, because of the highly faulted and disturbed condition revealed in the new Eska tunnel. On the south limb, where the fault zone is as much as 1,000 feet wide, this block may contain some relatively undisturbed coal in bodies large enough to mine; this is suggested by the apparently unfaulted condition of the Jonesville group where it crops out in the west half of the SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 16, on or near the axis of the syncline. However, in the absence of underground workings or extensive outcrops, no estimate of probable tonnage of minable coal in this block can be made.

The block bounded by the Eska and Jonesville fault zones includes, on the north limb of the syncline, the largest coal reserve in unit 7 (Eska mine). Part of this block lies in unit 6 but is separated from the active (north-limb) workings of the Evan Jones mine by the Jonesville fault. The strata of the north limb in this block are thought to include all the principal coal beds of the field, from the Eska group to the Jonesville group, inclusive (fig. 8). The north-limb workings of the Eska mine at the 960-foot level are now being extended westward in this block on beds of the Eska group. On the south limb the only coal beds extending above the level of the Evan Jones tunnel are those of

the Jonesville group, of which beds 3 and 4 were mined in the old south-limb workings, now abandoned. The Eska group and beds 5 to 8 probably lie south of and below these workings, but as the area in which they should crop out is covered by a deep mantle of slide rock their exact position and extent in this block are not known.

The block between the Jonesville fault and the west edge of the area mapped, at the boundary of coal-leasing unit 6, contains the largest known and potential coal reserves in the lower Matanuska Valley field. Bed 8 has been traced underground about 4,700 feet westward from the Evan Jones crosscut tunnel and is interrupted by only 3 or 4 faults of relatively small displacement. Beds 5 and 6 have been traced underground about 2,500 feet, and the sequence of coal beds that comprise beds 5 to 8 in the vicinity of the tunnel has been traced at the surface westward to the lease boundary, a distance of more than 2 miles. In the interval between the face of the gangway on bed 8 and the west boundary of the lease, surface evidence indicates at least three transverse faults in the overlying conglomerate with apparent horizontal displacements of the order of 100 feet (fig. 2). Near the face of the gangway on bed 8 is a fault along which the west side moved about 50 feet south. This fault may be the same as, or a branch of, the easternmost of the three faults detected at the surface. Although these faults when encountered underground will be obstacles to mining, the problem of recovering the coal beyond them will be simplified by the fact that the direction of displacement is known --- at each of the faults on the surface the west side moved south.

A small diabase dike cuts the coal-bearing strata at locality P (fig. 2). This dike, which was traced for several hundred feet, strikes about N. 45° W., is nearly vertical, and is about 20 feet thick. Its position and trend indicate that it would have been encountered underground if the gangway on bed 8 had been advanced 300 to 400 feet farther. The intrusion of this dike apparently had little effect on the enclosing strata, as coal within a few inches of the contact is practically unaltered. Evidently its effect on mining will be limited chiefly to the increased difficulty of driving gangways and crosscuts through the hard igneous rock.

Present evidence indicates that at least 5 minable coal beds are included in the north-limb section between the Evan Jones crosscut tunnel and locality O, and probably as far west as the leasing-unit boundary. These include one bed in the Jonesville group, probably corresponding to bed 3 of the south-limb section, three beds in the Premier group, and bed 8. Bed 4 of the Jonesville group could possibly be added to the list of minable beds, although its extent and thickness west of locality X are not known. Bed 2 is also of minable thickness, but so closely underlies bed 3 that both beds could be worked

only if it is found feasible to mine them together as one bed. Near the crosscut tunnel beds 5, 6, 7, and 8 have been mined, and beds 5 and 8 have been positively identified as far west as localities Q and O, respectively (fig. 3). The two thickest coal beds between beds 5 and 8 at locality Q may correspond to beds 6, 7, and 7A in the Evan Jones tunnel, but these correlations have not been confirmed.

A summary of estimated coal reserves in various parts of the area is presented in table 2. In computing tonnages the developed coal remaining in pillars above existing gangways was not included, so that the tonnages given represent coal in advance of the gangway faces at the end of 1944. In compiling the table no attempt was made to eliminate coal that is probably not minable, as for example coal that closely overlies beds that have been mined and caved, or coal that lies in such relation to another minable bed that only one of them can probably be recovered. However, the table is so arranged that separate figures are given for questionable blocks on individual beds, so that the reader can classify and eliminate certain blocks as non-recoverable in the light of his own knowledge and experience. For example, most of the 488,000 tons in bed 7B shown in the fourth column from the right in table 2 probably will never be recovered, as it closely overlies caved workings on bed 8, whereas the 370,000 tons shown in the next column to the right probably can be recovered, providing it is mined before the underlying bed 8.

The recoverability of certain blocks probably cannot be determined much in advance of actual mining, because of lack of information on thickness and intervals between beds. Thus beds 2 and 3 at most points are too close to be mined separately, and it may or may not be found feasible to mine them together; if not, the tonnages given for bed 2 should be deducted from the total reserves.

The figures given for average thickness of coal beds are based on measurements and are believed to be conservative for the areas in which they were applied. In determining the average thickness consideration was given to the probable thickness that would be mined in actual practice; bony roofs and footwalls were excluded in some beds, as also were thin benches separated from the main seam by partings of equal or greater thickness. In the westernmost block thickness measurements of most beds were available only near the eastern edge, so the average thicknesses used are in question, as indicated in the table. Beds averaging less than 2 feet in thickness were not included in the computations.

The figures given in table 2 for the block west of the Jonesville fault do not include coal on the south limb of the syncline, or coal on

the north limb below the 860-foot level except in the block east of the face of the gongway on bed 8. The coal beds probably are as extensive across the axis of the syncline as parallel to it. Therefore, on the basis of the approximate area underlain by the coal measures and the probable average total thickness of coal beds, it is estimated that at least 45 million tons of coal, in addition to that shown in table 2, underlie Wishbone Hill between the Jonesville fault and the western boundary of the leasing unit. Structural evidence indicates that the maximum depth of cover in this area is about 2,000 feet. The above estimate does not include bed 4 for which adequate data are not available, or any coal beds of the Eska group, which are not believed to be of minable thickness over any great extent west of the Jonesville fault.

On the basis of the above figures, the total estimated coal reserve in the eastern part of the lower Matanuska Valley coal field is approximately 70 million tons.

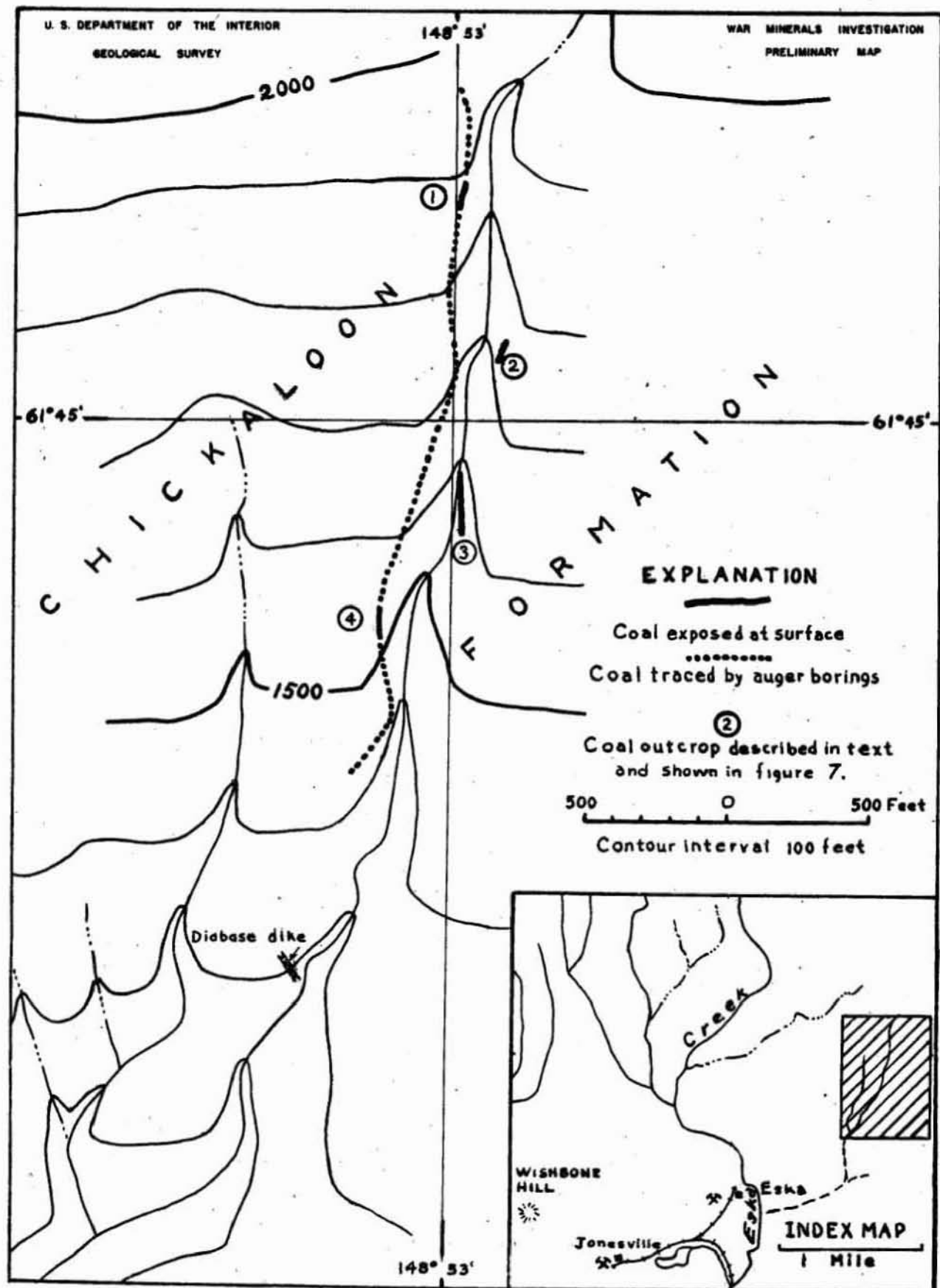


Figure 6.—Sketch map of coal deposits 1½ miles northeast of
Eska

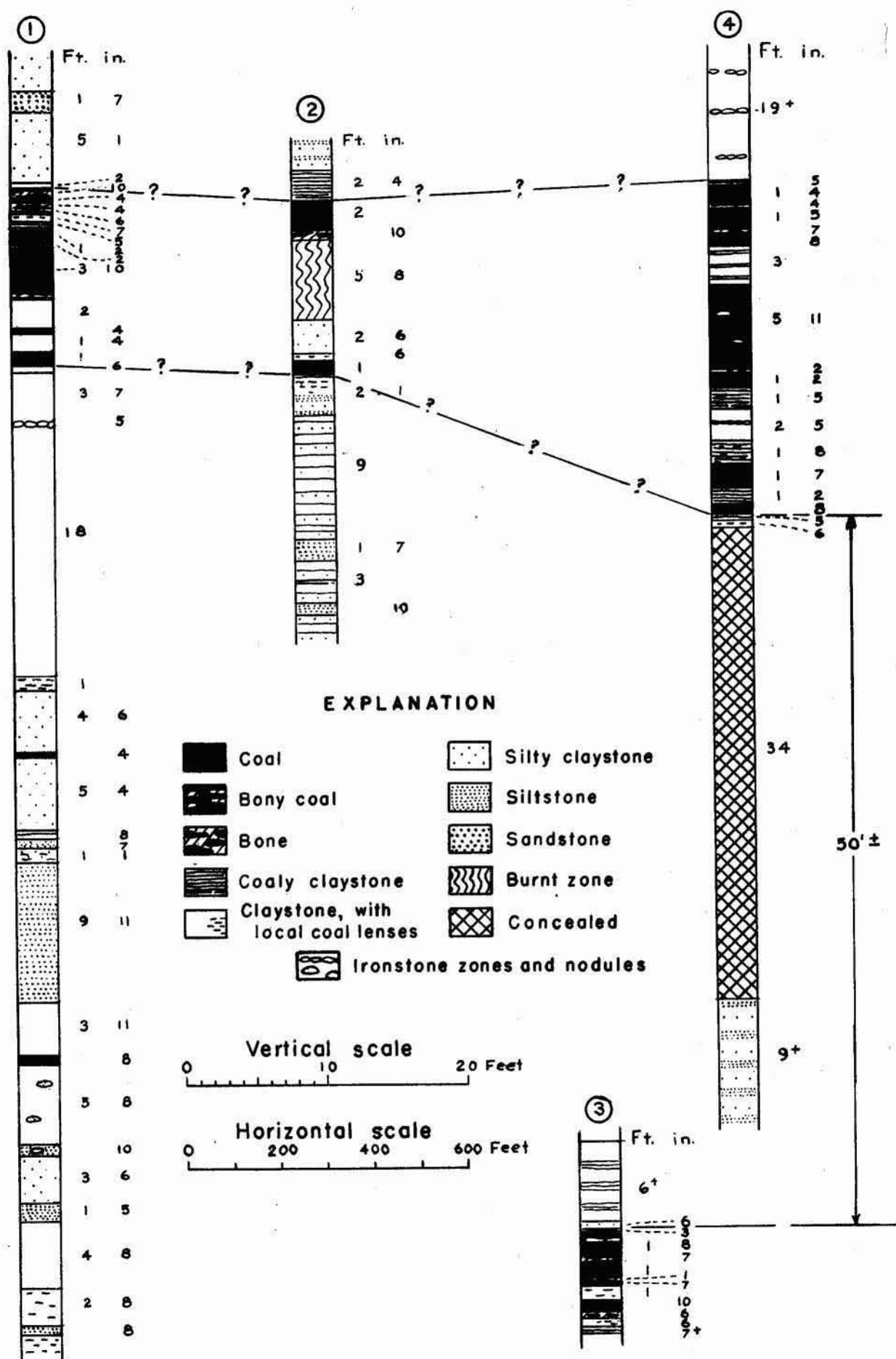


Figure 7.— Sections of coal beds exposed 1½ miles northeast of Eska

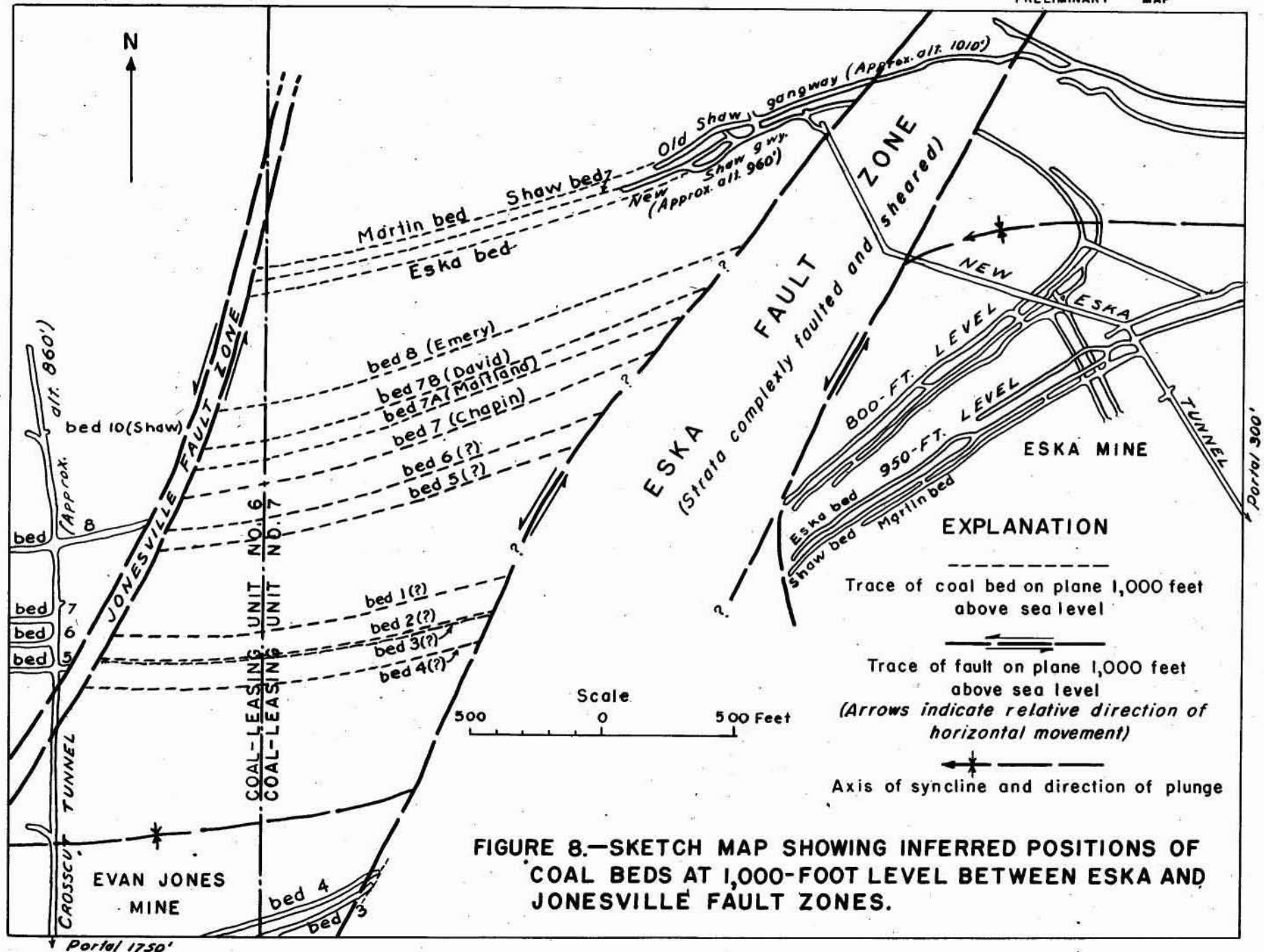


FIGURE 8.—SKETCH MAP SHOWING INFERRED POSITIONS OF COAL BEDS AT 1,000-FOOT LEVEL BETWEEN ESKA AND JONESVILLE FAULT ZONES.