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DEPARTMENT OF NATURAL RESOURCES

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Alaska Open-file Report 160
COAL OCCURRENCES AND ANALYSES,
FAREWELL-WHITE MOUNTAIN AREA, ALASKA

By
D.N. Solie and D.B. Dickey

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COAL OCCURRENCES AND ANALYSES, FAREWELL-WHITE MOUNTAIN AREA, ALASKA

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INTRODUCTION

Coal samples ranging in grade from lignite to high volatile C bituminous were collected from Tertiary sedimentary rocks along the northwest flank of the Alaska Range. The easternmost occurrence is in the McGrath B-2 Quadrangle south of Farewell, and the westernmost coals occur along the Cheeneetnuk River in the McGrath A-5 and Lime Hills D-6 Quadrangles. Coal outcrops on the Windy Fork of the Middle Fork of the Kuskokwim River, on two drainages west of the Windy Fork, and on the Middle Fork of the Kuskokwim River (fig. 1) are also described.

The Farewell fault zone trends N. 45° E. through the study area along the northwest flank of the Alaska Range and contains slivers of Tertiary nonmarine sedimentary rocks that include local coal-bearing sections from 5 to 190 m thick. The thickest section of coal-bearing rocks (described by Sloan and others, 1979) crops out on the west bank of the Windy Fork. Nearby coal was reported by Brooks (1910, 1911, 1925), who wrote:

> Beds of lignitic coal have, however, been found by W.E. Priestley in the region lying immediately southwest of the junction of the two forks of the Kuskokwim. In the valley of Big River, Mr. Priestley reports, there is considerable coal, some of which is in thick beds. A specimen of this coal indicates that it is a lignite of good grade (1911, p. 188).

Barnes (1967, p. B21) summarizes the Cheeneetnuk occurrences:

> Tertiary coal-bearing rocks are exposed at intervals for several miles along the Cheeneetnuk River, where they apparently have been downthrown against older rocks in a major fault zone. One exposure includes a 6-foot bed of bright brittle coal that is probably of bituminous rank.

Coals sampled in the Cheeneetnuk River area (Gilbert, 1981) are of variable quality (tables 1-3). These coals were also sampled by Sloan and others (U.S. Geological Survey, 1979), and previously unpublished analyses of their samples are shown in table 4.

Coal outcrops west of Khuchaynik Creek and on the Windy Fork (fig. 2) are described by D.B. Dickey (Gilbert and others, 1982), and Bundtzen and others (1982) describe small coal occurrences in Tertiary volcaniclastic sedimentary rocks west of Sheep Creek in the McGrath B-2 Quadrangle. Coal analyses from several well-known Alaskan coal fields are included for comparison in table 5 (Barnes, 1967, p. B14-B15).

Coal samples collected from weathered outcrops were not protected from loss of water by evaporation.

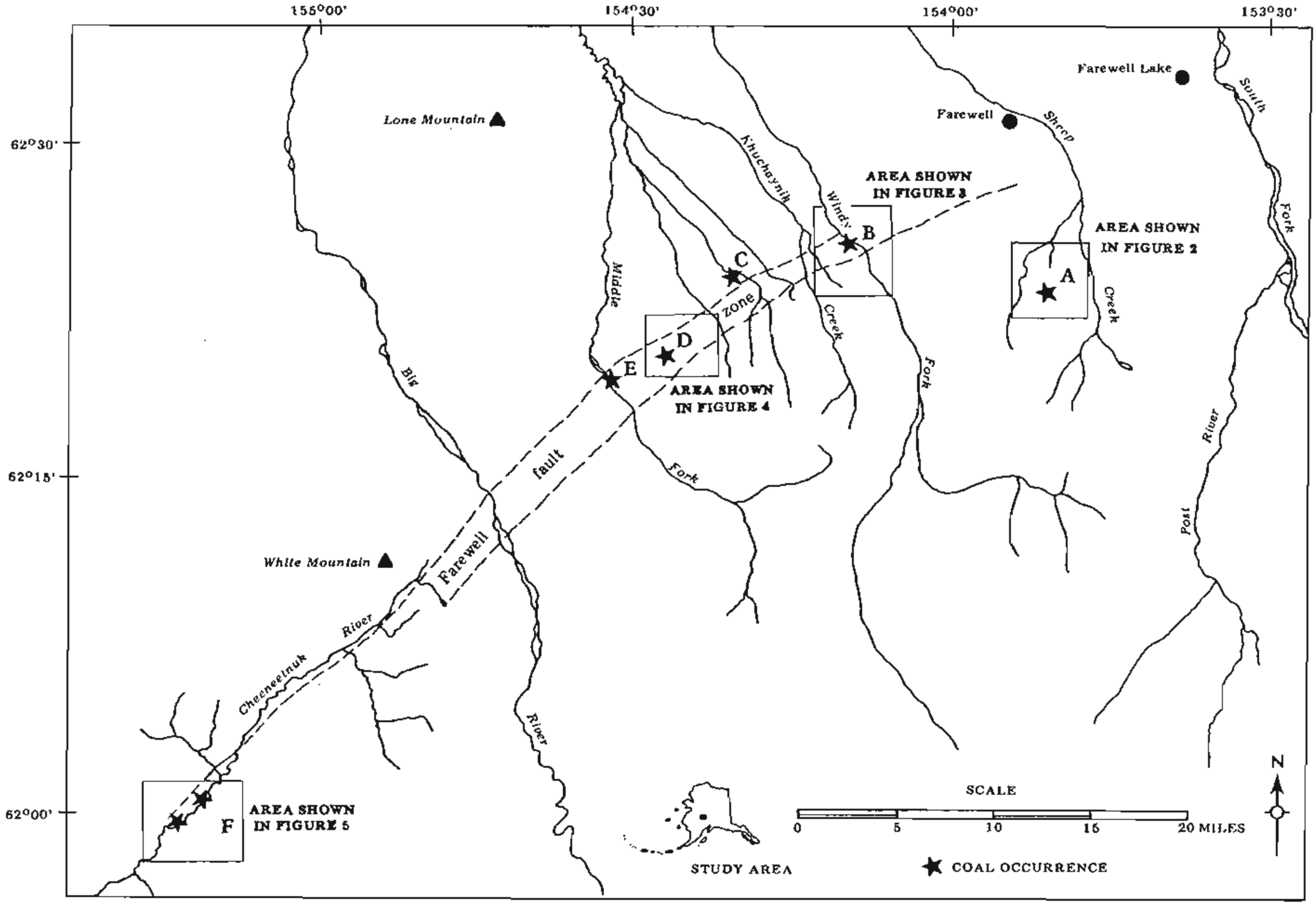

Figure 1. Location of study area, with general locations of coal occurrences A-F.

Table 1. Proximate and ultimate analyses of 1.6-specific-gravity float samples

Sample number and occurrence	Basis*	Moisture (%)	Volatile matter (%)	Fixed carbon (%)	Ash (%)	Heating value (Btu/lb)	C (%)	H (%)	N (%)	O (%)	Sulfur Pyritic	Sulfur Total	Moist m-m-free Btu, ASTM class
80BT150 occur. A	a	1.83	25.74	45.55	26.88	9,694	- -	- -	- -	- -	- -	0.55	13,774.4; hi vol C bitum.
81DB126 occur. B	a	13.24	29.37	46.88	10.51	9,482	56.33	5.10	1.41	31.42	0.12	0.33	10,725.5; subbit. A or hi vol C bitum.
	b	- -	33.85	54.04	12.11	10,929	64.93	4.17	1.62	20.95	0.14	0.38	
	c	- -	38.52	61.48	- -	12,435	73.88	4.75	1.84	19.09	0.15	0.44	
81DB135 occur.B	a	10.77	31.18	39.96	18.09	8,912	51.69	4.90	1.93	27.57	0.15	0.72	11,135.9; subbit. A or hi vol C bitum.
	b	- -	34.94	44.78	20.27	9,988	57.93	4.14	2.16	18.83	0.16	0.80	
	c	- -	43.83	56.17	- -	12,527	72.66	5.19	2.71	18.43	0.21	1.01	
81DB139C occur. B	a	11.48	32.08	45.54	10.90	9,841	57.39	5.28	1.64	29.46	0.23	0.61	11,189.4; subbit. A or hi vol C bitum.
	b	- -	36.24	51.44	12.31	11,117	64.83	4.51	1.86	20.31	0.26	0.69	
	c	- -	41.33	58.67	- -	12,678	73.93	5.15	2.12	18.02	0.30	0.79	
81DB139D occur. B	a	12.79	30.72	48.87	7.62	9,990	58.87	5.28	1.81	31.19	0.04	0.51	10,910.0; subbit A or hi vol C bitum.
	b	- -	35.23	56.04	8.74	11,455	67.51	4.41	2.07	21.10	0.04	0.59	
	c	- -	38.60	61.40	- -	12,552	73.97	4.83	2.27	18.29	0.05	0.65	
81DB139F occur. B	a	9.58	33.16	49.41	7.85	10,808	62.46	5.32	1.37	27.81	0.04	0.51	11,836.1; hi vol C bitum.
	b	- -	36.67	54.64	8.68	11,953	69.08	4.70	1.52	20.16	0.04	0.56	
	c	- -	40.16	59.84	- -	13,089	75.64	5.15	1.66	16.93	0.04	0.62	
81DB329A occur. D	a	26.42	30.99	32.09	10.50	6,709	42.27	5.66	1.65	45.25	0.06	0.33	7,587.9; lignite A.
	b	- -	42.12	43.61	14.27	9,118	57.45	3.67	2.24	25.59	0.09	0.45	
	c	- -	49.13	50.87	- -	10,636	67.01	4.28	2.61	25.57	0.10	0.52	
79WC01B occur. F	a	9.28	37.54	38.09	15.09	9,721	52.50	4.98	1.56	24.66	3.79	6.19	11,742.9; hi vol C bitum.
	b	- -	41.38	41.98	16.64	10,715	57.87	4.34	1.72	16.96	4.18	6.82	
	c	- -	49.64	50.36	- -	12,853	69.42	5.21	2.06	15.13	5.01	8.19	
79WC02B occur. F	a	12.53	32.51	44.79	10.18	9,782	56.95	5.02	1.61	30.85	0.20	0.40	11,020.5; subbit A or hi vol C bitum.
	b	- -	37.16	51.21	11.63	11,183	65.11	4.14	1.84	20.95	0.23	0.46	
	c	- -	42.05	57.95	- -	12,655	73.68	4.68	2.09	19.03	0.26	0.52	
79WC02C occur. F	a	11.41	36.87	47.56	4.16	10,934	62.87	5.50	1.87	30.51	0.17	0.59	11,465.4; subbit. A or hi vol C bitum.
	b	- -	41.61	53.69	4.70	12,342	70.96	4.77	2.11	21.56	0.19	0.67	
	c	- -	43.66	56.34	- -	12,950	74.46	5.01	2.21	17.62	0.20	0.70	
79WC03B occur. F	a	16.53	36.49	42.15	4.83	9,706	56.33	5.68	1.50	35.82	0.43	1.53	10,267.2; subbit. B
	b	- -	43.72	50.50	5.78	11,628	67.48	4.59	1.79	23.11	0.52	1.84	
	c	- -	46.40	53.60	- -	12,341	71.62	4.87	1.90	19.65	0.55	1.95	

*Basis
a Equilibrium moisture
b Moisture free
c Moisture and ash free

Table 2. Float-sink separation of raw coals at 1.6 specific gravity

Sample	Product	Weight (%)	Air-dry-basis Moisture (%)	Air-dry-basis Ash (%)
81DB126	Float	75.26	3.79	11.65
	Sink	24.74	1.91	58.00
	Raw coal (calculated)	100.00	3.32	23.12
81DB135	Float	24.12	2.98	19.67
	Sink	75.88	2.26	58.15
	Raw coal (calculated)	100.00	2.43	48.87
81DB139C	Float	61.03	4.15	11.80
	Sink	38.97	2.51	60.15
	Raw coal (calculated)	100.00	3.51	30.64
81DB139D	Float	78.22	3.40	8.44
	Sink	21.78	1.64	58.65
	Raw coal (calculated)	100.00	3.02	19.38
81DB139F	Float	43.29	2.44	8.47
	Sink	56.71	1.49	63.81
	Raw coal (calculated)	100.00	1.90	39.85
81DB329A	Float	17.67	6.22	13.38
	Sink	82.33	3.04	56.14
	Raw coal (calculated)	100.00	3.60	48.58
79WG01B	Float	83.78	3.34	16.08
	Sink	16.22	2.94	30.53
	Raw coal (calculated)	100.00	3.28	18.42
79WG02B	Float	86.51	4.58	11.10
	Sink	13.49	2.82	43.55
	Raw coal (calculated)	100.00	4.34	15.48
79WG02C	Float	98.37	4.19	4.50
	Sink	1.63	2.45	35.97
	Raw coal (calculated)	100.00	4.16	5.01
79WG03B	Float	99.54	5.26	5.48
	Sink	0.46	3.20	16.54
	Raw coal (calculated)	100.00	5.25	5.53

Table 3. Reflectance of vitrinite

Sample number		RMO* Mean reflectance	V3	V_4	V_5	V_6	V_7
80BT150	Low rank bituminous	0.8					
81DB126	Low rank bituminous	0.67				86	14
81DB135	Low rank bituminous	0.63			12	72	16
81DB139C	Low rank bituminous	0.53		8	92		
81DB139D	Low rank bituminous	0.58			54	46	
81DB139F	Low rank bituminous	0.52		12	88		
81DB329A	Low rank bituminous	0.57			58	42	
79WG1B	Subbituminous	0.43	24	68	8		
79WG2B	Low rank bituminous	0.53		22	78		
79WG2C	Low rank bituminous	0.54		10	78	12	
79WG3B	Low rank bituminous/subbituminous	0.50		28	72		

*Based on 50 readings.

Table 4. Proximate and ultimate analyses of Cheeneetnuk River coals (collected by U.S. Geological Survey, analysed by U.S. Department of Energy laboratory)

Sample number	Basis*	Moisture (%)	Volatile matter (%)	Fixed carbon (%)	Ash (%)	Heating value (Btu/lb)	C (%)	H (%)	N (%)	O (%)	S (%)	Moist m-m-free Btu and ASTM class.
TS79-1	a	15.6	39.7	39.4	5.3	10,026	58.6	5.7	1.5	27.5	1.3	10,661; hi vol C bitum or subbit A.
	b	- -	47.0	46.7	6.3	11,876	69.4	4.8	1.7	16.2	1.6	
	c	- -	50.1	49.9	- -	12,676	74.1	5.1	1.9	17.3	1.7	
TS79-2	a	27.1	30.0	33.7	9.2	7,849	46.2	6.2	1.4	36.3	0.7	8,739; subbitum C.
	b	- -	41.2	46.2	12.6	10,768	63.3	4.4	1.9	16.8	0.9	
	c	- -	47.1	52.9	- -	12,324	72.5	5.1	2.1	19.2	1.1	
TS79-3	a	26.6	30.8	34.9	7.7	8,119	47.8	6.1	1.3	36.4	0.7	8,877; subbitum C.
	b	- -	42.0	47.5	10.5	11,058	65.1	4.3	1.8	17.3	0.9	
	c	- -	46.9	53.1	- -	12,350	72.7	4.8	2.0	19.5	1.0	
TS79-5	a	20.1	31.8	41.6	6.5	9,611	55.0	6.1	1.7	30.0	0.7	10,359; subbitum B.
	b	- -	39.9	52.0	8.1	12,031	68.8	4.8	2.2	15.2	0.9	
	c	- -	43.4	56.6	- -	13,090	74.9	5.3	2.3	16.6	1.0	

*Basis
- a As received
- b Moisture free
- c Moisture and ash free

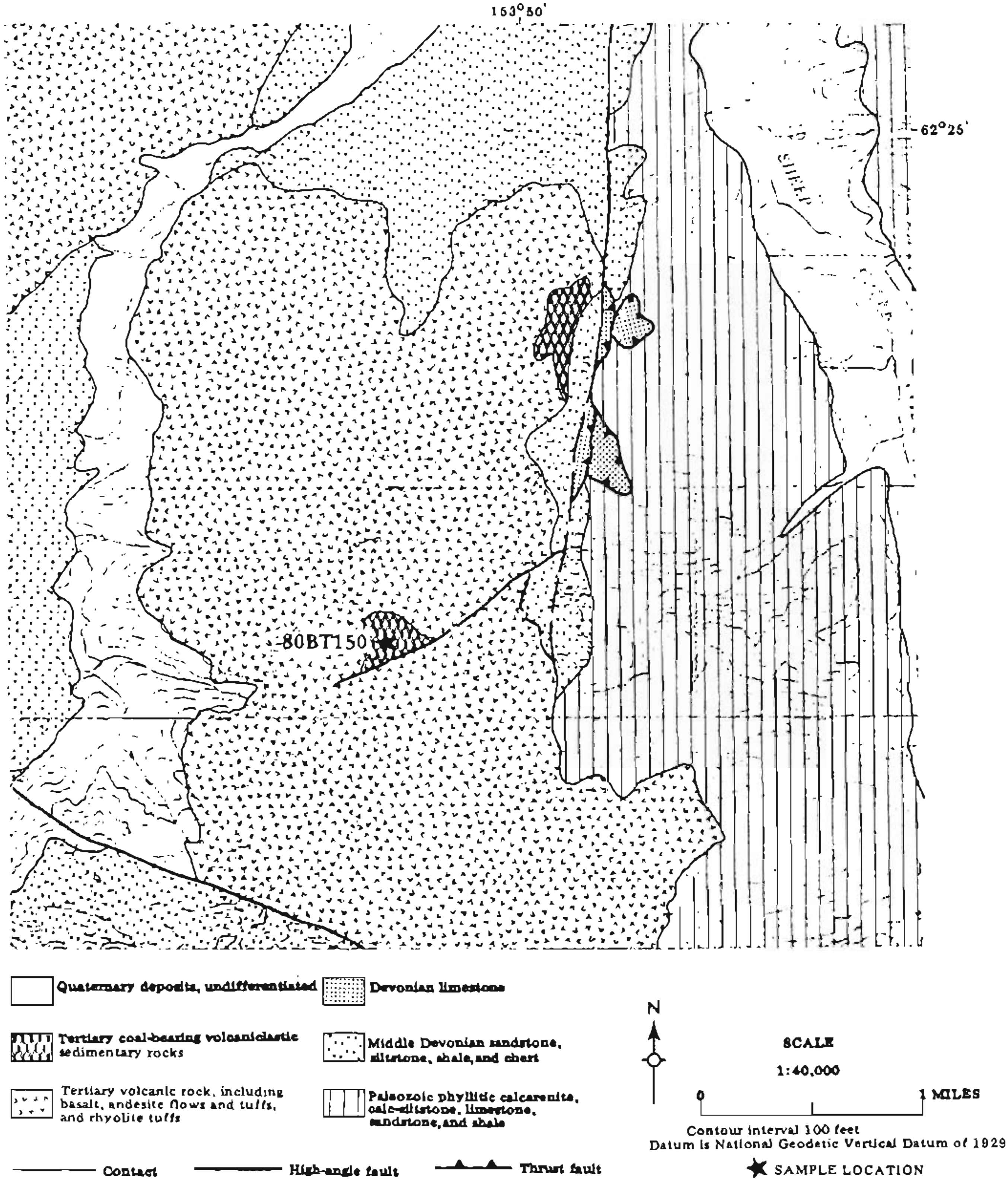

Figure 2. Location map, occurrence A, showing generalized geology and sample location (geology modified from Bundtzen and others, 1982).

Table 5. Range in composition and heating value of representative coals from some Alaskan coal fields (from Barnes, 1967, on 'as received' basis)

Location	Moisture (%)	Volatile matter (%)	Fixed carbon (%)	Ash (%)	Sulfur (%)	Heating value (Btu/lb)
Nenana coal field (outcrop)	11.7-32.7	31.2-42.9	22.7-36.6	3.3-15.9	0.1-0.4	6,320-10,385
Jarvis Creek coal field	20.0-23.0	35.1-43.4	24.1-35.3	5.2-13.1	0.3-1.4	7,815-9,415
Susitna coal field (outcrop)	19.7-28.2	30.1-39.9	28.7-40.6	2.0-14.2	0.1-0.4	8,060-9,520
Matanuska coal field Anthracite Ridge district (outcrop)	1.9-6.8	14.3-31.5	47.4-78.4	2.4-17.2	0.5-0.7	11,300-14,210

Coal rank was determined by the 1980 ASTM standards classification (Crelling and Dutcher, p. 38), and Btu's per pound (moist, mineral-matter-free basis) were calculated using the standard ASTM approximation formula:

$$\text{Moist, m-m-free Btu} = \frac{\text{Btu}}{100-(1.1A + 0.1S)} \times 100$$

Btu = British thermal units
A = ash percentage
S = sulfur percentage

All terms from equilibrium moisture basis analysis.

Rank classification on the basis of reflectance of vitrinite is from Karr (1978).

ACKNOWLEDGMENTS

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COAL OCCURRENCES

Occurrence A 2-1/2 miles west of Sheep Creek; McGrath B-2 Quadrangle, T. 27 N., R. 25 W., Sec. 35, 25, Seward Meridian.

Two thin coal seams crop out in a unit of Tertiary volcaniclastic sedimentary rocks and air-fall tuff (unit Tvs; Bundtzen and others, 1982) at an elevation of 5,100 ft (fig. 2). The bone-coal seams range in thickness from 10 cm to over 1 m, are interbedded within fine- to medium-grained, brown to gray, dirty sandstone, shale, and siltstone and contain abundant plant stems, Meta sequoia, and dicotyledon leaves. Fossil fauna identified by C.J. Smiley (written commun., 1982) indicate a Paleocene-Eocene age. Coalified stumps and stems occur in thin paleosols interbedded with air-fall tuff just south of the sampled coal seam; coal rubble was also noted in sandstone (unit Tvs) 1-1/2 miles to the northeast. These occurrences are probably not significant because of the sparsity of coal and limited extent of coal-bearing units. Analysis of the 18-in.-thick bone-coal seam yielded a Btu content of approximately 9,700.

Occurrence B Windy Fork; McGrath B-3 Quadrangle, T. 27 N., R. 26 W., sec. 19, 20, Seward Meridian.

A measured section of Tertiary nonmarine sedimentary rocks along the Windy Fork of the Kuskokwim River includes a 190-m-thick section of carbonaceous shale and coal (pl. 1, fig. 3). Five coal samples were analyzed from the measured section (tables 1-3); samples 81DB139C, D, and F are from the 190-m-thick coal-bearing section and sample 81DB135 is from a 20-m-thick coal layer lower in the section. Sample 81DB126 was collected from a 7-m-thick seam near the base of the measured sequence. Most beds strike to the northeast and dip northwest; however, the upper coal-bearing zone is in a broad synform. The section includes conglomerate, sandstone, siltstone, shale, and coal.

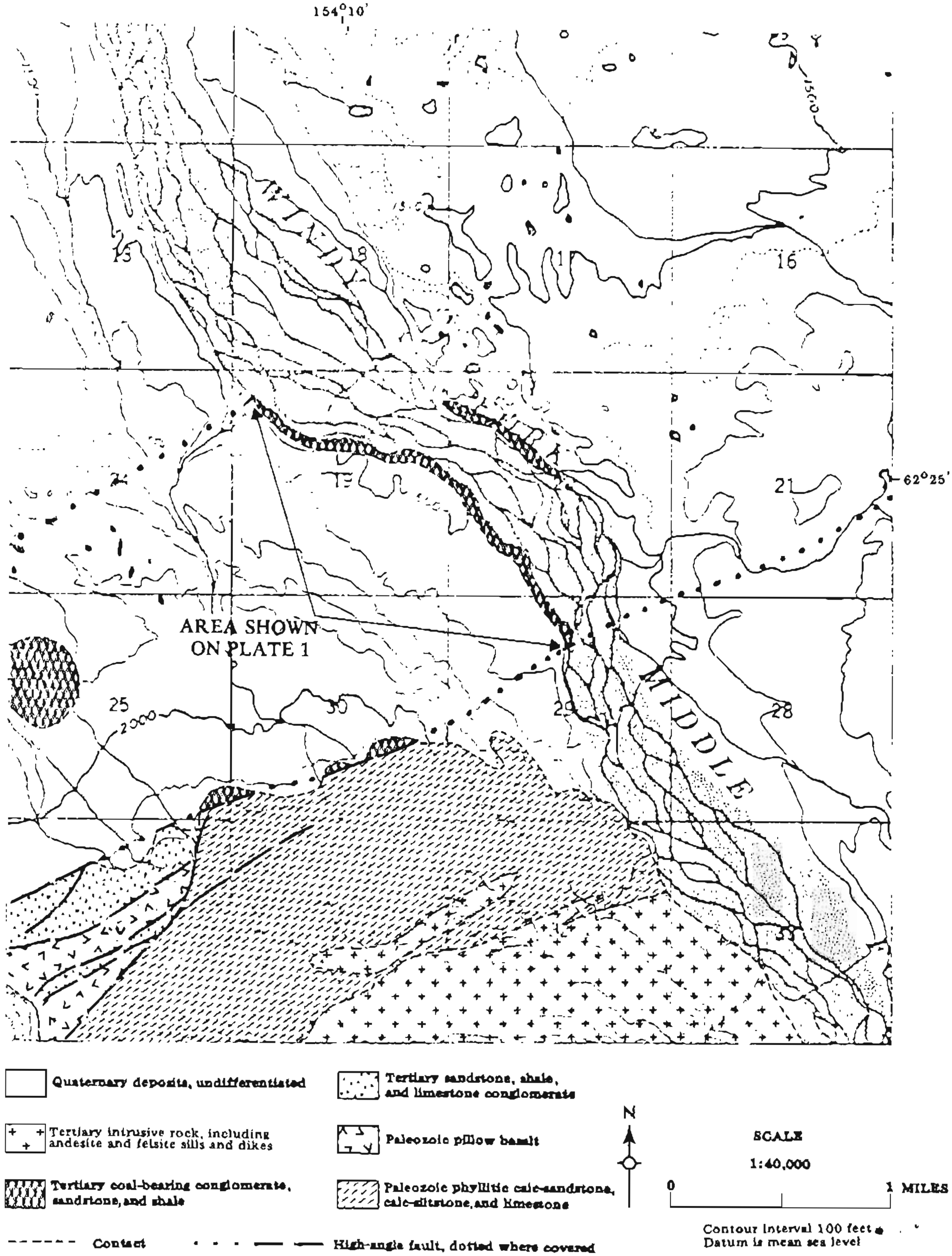

Figure 3. Location map, Windy Fork occurrence, showing generalized geology (geology modified from Gilbert and others, 1982).

Sandstone petrography indicates the clastic rocks were derived from a low-grade metamorphic terrane (Dickey and others, 1982). The section fines upward in cycles, and periods of very slow deposition alternate with periods of rapid deposition. The rapid deposition is represented by thick, cross-bedded channel conglomerate, and shale, siltstone, and mudstone represent interchannel deposits. Some conglomerates and sandstones include substantial quantities of woody material, now coalified. The paleoenvironment probably consisted of alluvial and fluvial systems draining highlands to the north during the Oligocene and Miocene Epochs.

The Windy Fork coals rank in grade from subbituminous A to high volatile C bituminous according to the ASTM classification; they are low rank bituminous on the basis of reflectance of vitrinite. Sulfur content is fairly low, and ash content is as high as 20.27 percent in proximate analysis (sample 81DB135).

Occurrence C McGrath B-3 Quadrangle, T.27 N., R. 27 W., sec. 32, Seward Meridian.

A solitary bluff of Quaternary glacial till and green clay (probably fault gouge), and coal of unknown age occurs along the western edge of the unnamed river in figure 1. The coal layer (thickness less than 2 m, unknown lateral extent) was not sampled for analysis because it was highly weathered and slumped. This coal may not be related to others in the McGrath Quadrangle, because no Tertiary clastic sediments are found in the area.

Occurrence D 81DB329A; McGrath B-3 Quadrangle, T. 26 N., R. 28 W., sec. 15, Seward Meridian.

Sandstone, siltstone, shale, and coal crop out along the west bank of this unnamed creek that cuts the Farewell fault zone (fig. 4). Sample 81DB329A was taken from two 25-cm-long channels that extend into the outcrop 5 to 15 cm. The bedding strikes N. 47° E., dips 49° SE., and is part of the south limb of a broad anticline whose axis trends subparallel to the fault zone.

The sandstone, siltstone, and shale resemble similar units throughout the Farewell fault zone. This coal-bearing outcrop is along strike with the coal-bearing section of the Windy Fork and may be stratigraphically equivalent. The northern extent of this unit is unknown because surficial materials obscure underlying bedrock.

Occurrence E McGrath B-4 Quadrangle, T. 26 N., R. 28 W., sec. 30, 31, Seward Meridian.

The Middle Fork of the Kuskokwim River cuts the coal-bearing section described for the Windy Fork occurrence and occurrence D. A 600-m-thick measured section (oriented N. 26° E., 45° NW., pl. 1) includes 35 m of coal and carbonaceous shale. The coal-bearing sequence is probably thicker than measured, but the top of the section is obscured by vegetation and colluvium. Lack of accessibility prevented sampling, but the quality of the coal may be comparable to that of the Windy Fork occurrence.

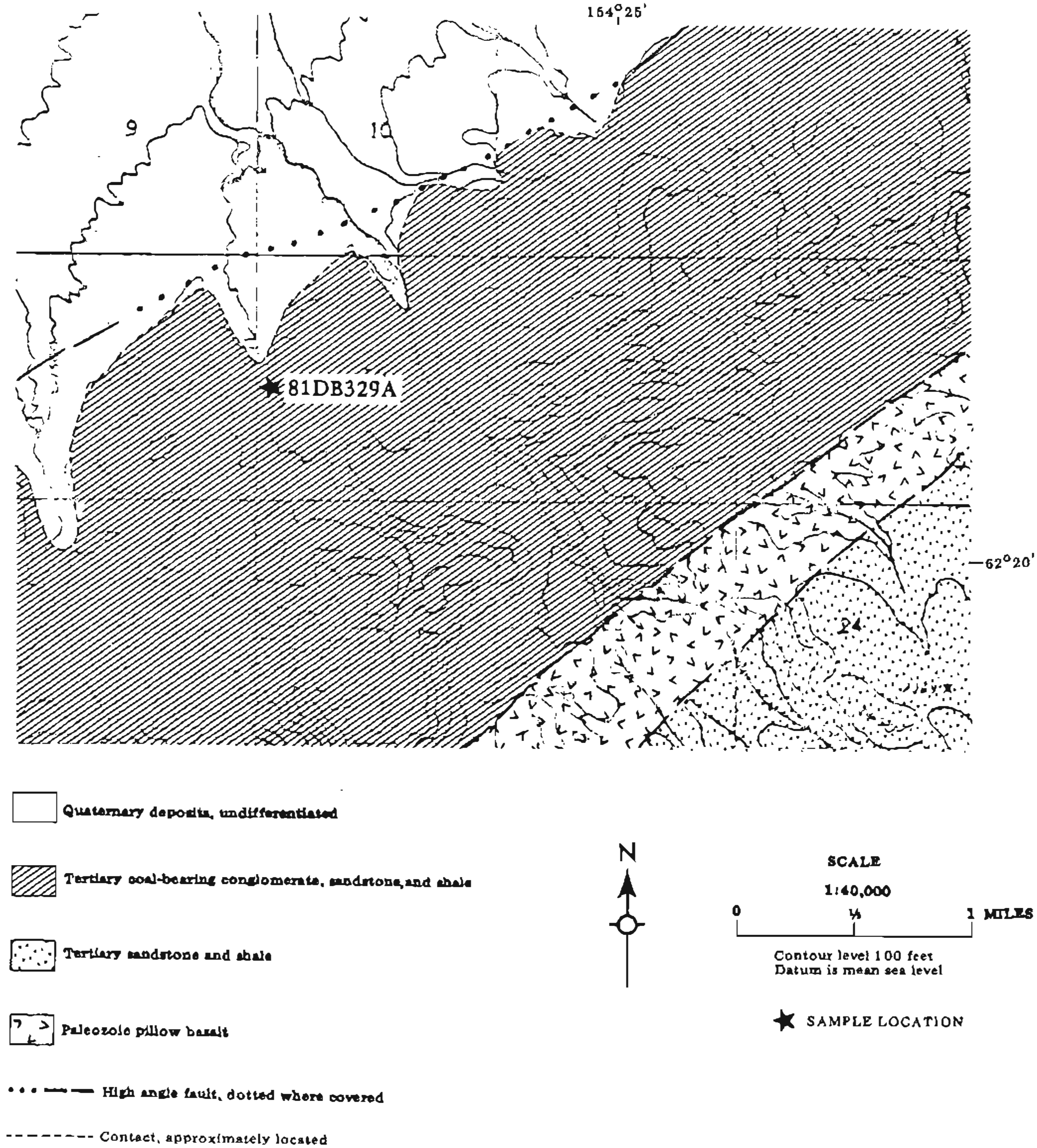

Figure 4. Location map, occurrence D, showing generalized geology and sample location (geology modified from Gilbert and others, 1982).

Occurrence F Cheeneetnuk River; Samples 79WG01-02, McGrath A-5 Quadrangle, T. 22 N., R. 32 W., sec. 8, Seward Meridian. Sample 79WG03, Lime Hills D-6 Quadrangle, T. 22 N., R. 32 W., sec. 18, Seward Meridian.

Southwest of White Mountain, the Cheeneetnuk River drains an area transected by the Farewell fault zone. Coal-bearing Tertiary rocks overlie Devonian limestone in a graben bounded by strands of the Farewell fault (Gilbert, 1981). These medium- to thin-bedded, laminated, moderately sorted, friable, micaceous sandstones and siltstones (with carbonaceous partings) contain fossil flora suggestive of a Late Miocene age. Outcrops of this unit along the Cheeneetnuk River contain brittle coal beds up to 0.5 m known thickness.

Samples were taken from three locations (fig. 5). The furthest upstream sample (79WG01B) is from a bed of friable coal 35-50 cm thick in a 4-m-high bluff of Tertiary sandstone. The coal contains ferruginous laminae with an attitude of approximately N. 10 E., 70-75° NW. Just downstream, a 46-cm-thick coal seam is exposed in two outcrops 30 m apart, in Tertiary sandstones dipping gently into the bluff (samples 79WG02B, 79WG02C).

Sample 79WG03B is from a 15-m-high bluff capped by Quaternary deposits more than 1-1/2 km downstream from previously described exposures. The lower 8-10 m of the bluff contains the coal-bearing Tertiary unit. Two vertical strips of coal were observed, each 4-5 m wide, but of little depth into the bluff. Thickness of the seam was not determined because the coal probably strikes parallel to the bluff with a vertical dip; the observed strips are only a thin remnant veneer of the vertical coal seam. Much coal float was observed further downstream along the bluff.

Analyses of the Cheeneetnuk River coal samples (tables 1-3) show rank determinations ranging from subbituminous B to high volatile C bituminous. The average of the four analyses yields a moist, mineral-matter-free Btu of 11,124 and a grade of subbituminous A or high volatile C bituminous. Reflectance of vitrinite measurements indicate rank in the same range, between subbituminous and low grade bituminous. Ash content as measured in the float-sink separation is low to moderate.

Sulfur content in two samples is high, especially in sample 79WG01B (compare with analyses, tables 1 and 5) with a moisture and ash-free total sulfur content of 8.19 percent. Ferruginous laminae, probably pyritic in origin, were noted in the field description, and laboratory analysts report some framboidal pyrite (fig. 6), which indicates a strongly-reducing, organic-rich environment of deposition (Caruccio and others, 1977, p. 46). High sulfur content is evidently localized, because nearby samples 79WG02B and 79WG02C have a significantly lower sulfur content.

The Cheeneetnuk River coals are relatively high in grade (subbitumious to bituminous), but the generally thin seams, variable attitudes of beds, and fault-bounded nature of the coal-bearing unit limit their extent.

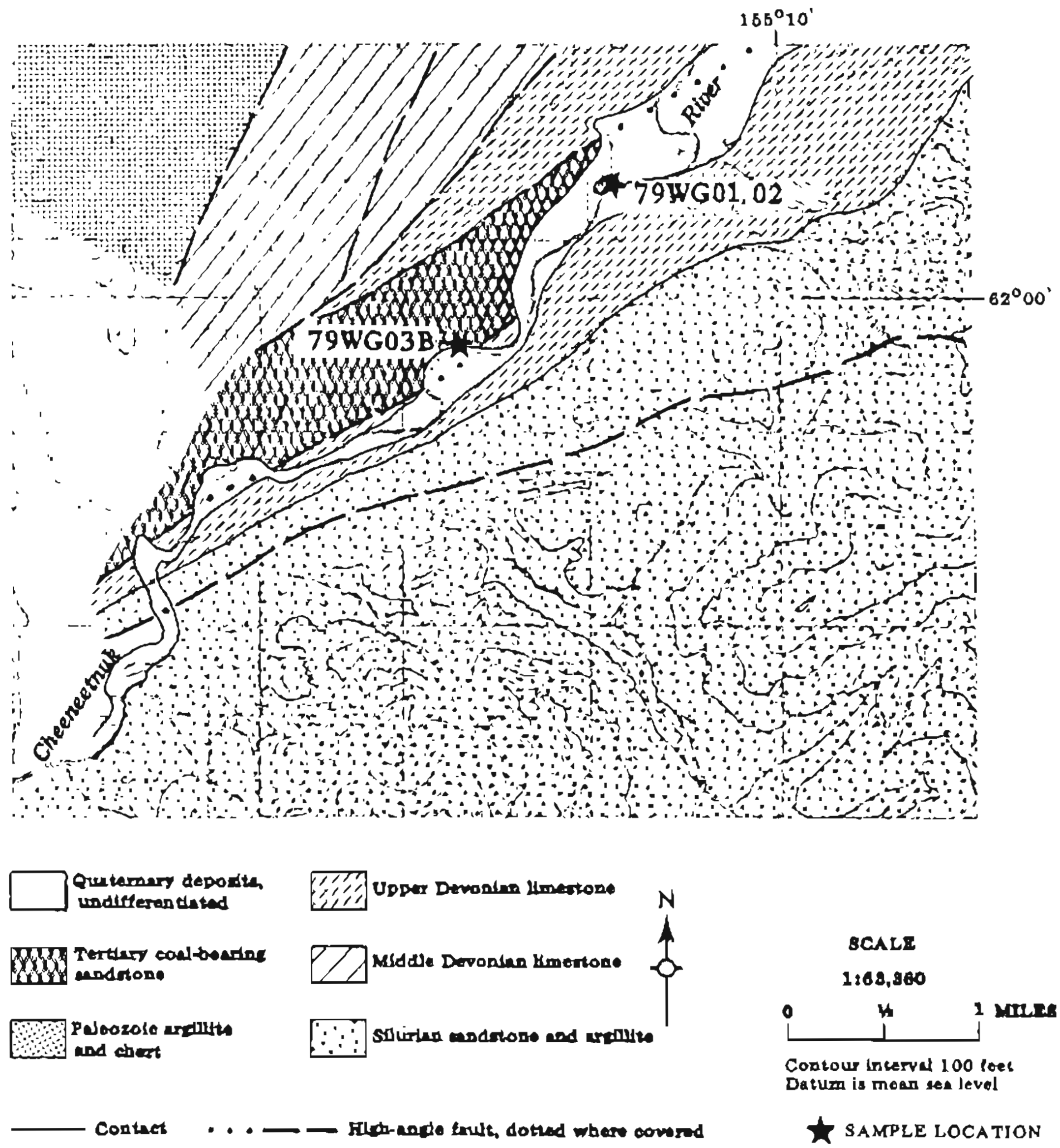

Figure 5. Location map, Cheeneetnuk River occurrence, showing generalized geology and sample locations (geology modified from Gilbert, 1981).

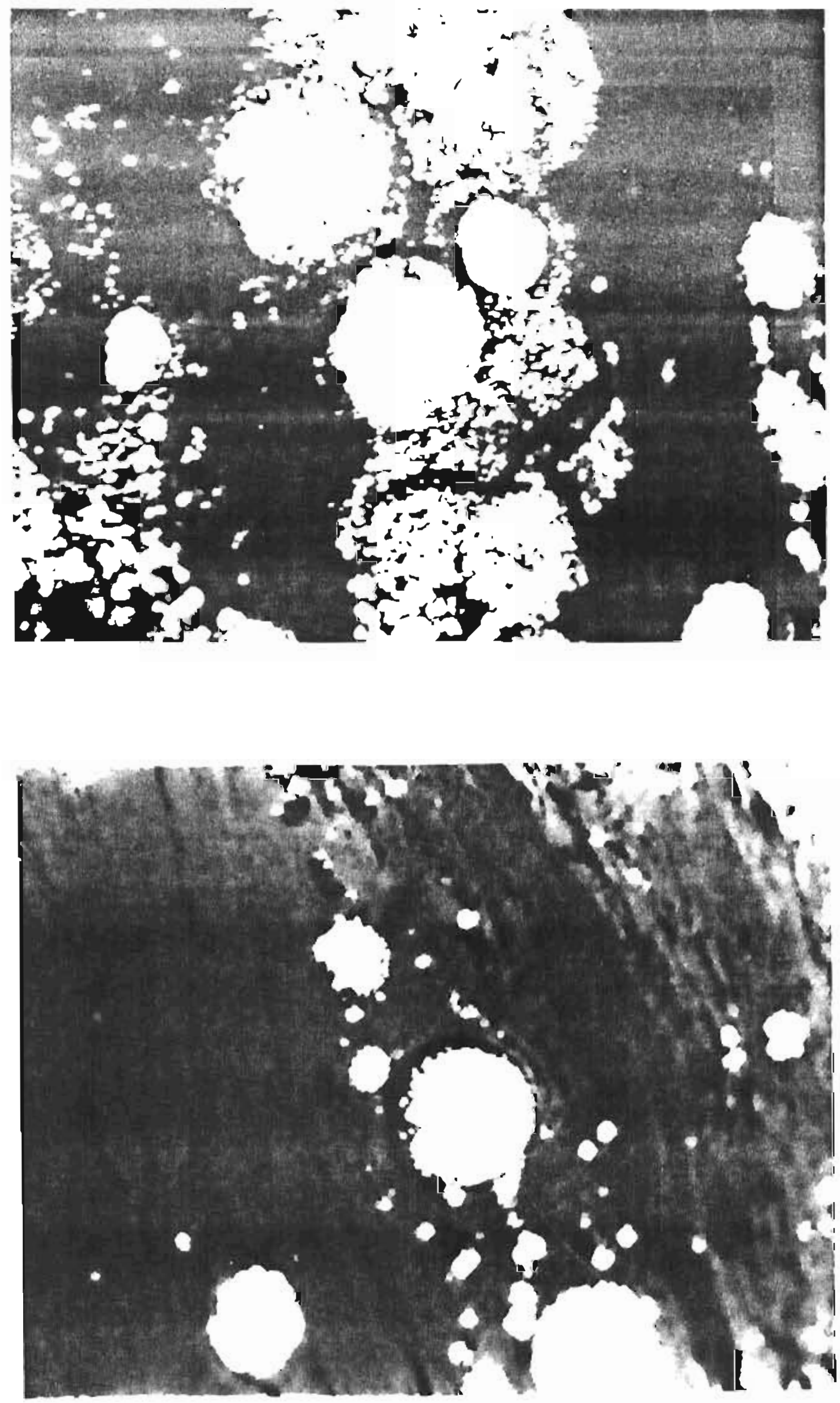

Figure 6. Photomicrographs of framboids in Cheeneetnuk River coal sample 79WG01B (photographs by Jane Smith, University of Alaska Mineral Industry Research Laboratory).

CONCLUSIONS

The above described coal occurrences in the Farewell-White Mountain area represent coal resources of unknown extent in and near the Farewell fault zone. The coals range from high volatile C bituminous to subbituminous A in zones of interbedded shale, mudstone, and coal up to 190 m thick.

Occurrences A and C are located outside the Farewell fault zone. The coal in Occurrence A is interbedded with volcanogenic, flora-bearing strata of Paleocene to Eocene age, and Occurrence C contains coal in sediments of unknown age north of the fault. The Windy Fork, Middle Fork, unnamed creek (Occurrence D), and Cheeneetnuk River occurrences are associated with sedimentary rocks ranging from Oligocene to Miocene in age. These and other similar Tertiary rocks crop out discontinuously along the Denali fault system. These discontinous Tertiary outcrops probably represent displaced portions of a larger basin that existed to the northeast during early to middle Tertiary time. Right-lateral offset along the Farewell fault is documented by Dickey and others (1982). Coal in the Little Tonzona River area (approximately 150 km to the northeast in the Talkeetna Quadrangle) occurs in a very similar geologic environment in Tertiary sedimentary rocks in the Farewell fault zone (Sloan and others, 1979); it is probably related to the Farewell fault zone coals discussed in this report. Extent of the coal beds is unknown to the north and limited to the south by splays of the Farewell fault. Although structurally deformed, the beds may persist extensively in the fault zone.

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