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COAL RESOURCES OF NORTHWEST ALASKA: FINAL REPORT

by

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In cooperation with the U.S. Geological Survey

Alaska Division of
Geological and Geophysical Surveys

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TABLE OF CONTENTS

Page

Page

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES
(plates in pockets)

[list of plates continued]
(plates in pockets)

INTRODUCTION

In 1988 the State of Alaska Division of Geological and Geophysical Surveys (ADGGS) entered into Cooperative Agreement No. 14-08-0001-A0668 with the U.S. Geological Survey to enter point source coal data from northwestern Alaska into the National Coal Resource Data System (NCRDS), a nation-wide network linked to the computing facilities in Reston, VA. The NCRDS provides a convenient means for archiving, retrieval, and analyzing coal information for resource estimates and basin studies. Encoded and formatted coal data has been provided by ADGGS on floppy diskette media for inclusion into NCRDS within the USTRAT (stratigraphic) and USALYT (analytical) point data files. The data entry procedure is one of continual updating and therefore the process is ongoing. To date 125 Point IDs with 231 coal quality analyses representing all data from 13 sites in northwestern Alaska and additional data from other sources have been entered by ADGGS into the NCRDS (localities 1-13, table 1).

TABLE 1

Number of Point IDs and coal quality data
entered by ADGGS into NCRDS, by locality and number

No.	*Locality*	*Number of coal quality analyses*	*Number of Point IDs*
1)	Cape Beaufort-Deadfall Syncline	88	50
2)	Cape Lisburne	19	19
3)	Kallarichuk River	2	2
4)	Hockley Hills	2	2
5)	Singauruk River	4	3
6)	Chicago Creek	85	18
7)	Turner Creek	1	1
8)	Sinuk River	1	1
9)	Wilson Creek	1	1
10)	Grouse Creek	2	2
11)	Koyuk	17	17
12)	Unalakleet	3	3
13)	St. Lawrence Island	6	6
	TOTAL	231	125

This report is a summary of the history, geology, and coal resources of northwestern Alaska to supplement the information entered into the National Coal Resource Data System. A detailed final report encompassing ADGGS coal studies in northwest Alaska and utilizing the database management and graphics capabilities of NCRDS is in preparation.

Coal in northwestern Alaska occurs within Lower Mississippian, Cretaceous, and Tertiary rocks. Coal quality and the extent of coal resources depends largely on their geologic age and tectonic setting. The oldest and highest rank coals (bituminous to semianthracite) of the Lower Mississippian rocks exposed on Cape Lisburne are in a structurally complex setting making resource estimates unreliable. The thickest individual coal beds (up to 100 ft thick) are also the youngest and lowest in rank (lignite) occurring in numerous isolated Tertiary basins scattered across Seward Peninsula, St. Lawrence Island and Norton Sound to Kobuk River areas. Many of these basins are undergoing Cenozoic subsidence and their relationship to one another is poorly understood. The best resources of coal in both known areal extent and high quality (subbituminous to high volatile C and B) occur in Cretaceous rocks in the region extending north of the Brooks Range.

Between 1980 and 1985 the ADGGS' Northwest Alaska Coal Project examined occurrences of lignite to bituminous coal in northwestern Alaska to consider the practicality of coal as an alternative energy source for the 28 villages in the region. The 13 most promising sites (Fig. 1) were investigated by geologists from ADGGS and U.S. Bureau of Land Management (BLM) and are (from north to south): 1) Cape Beaufort-Deadfall Syncline; 2) Cape Lisburne; 3) Kallarichuk River; 4) Hockley Hills; 5) Singauruk River; 6) Chicago Creek; 7) Turner Creek; 8) Sinuk River; 9) Wilson Creek; 10) Grouse Creek; 11) Koyuk; 12) Unalakleet; and 13) St. Lawrence Island. Beginning in 1981, Requests for Proposals (RFPs) for subcontractors to conduct test-drilling at six sites (Cape Beaufort, Chicago Creek, Sinuk River, Koyuk, Unalakleet, and St. Lawrence Island) were solicited from drilling companies and consulting geologists. Drill site and coal occurrence studies included drill-hole coring and lithologic/geophysical logging; field examinations and trenching of coal outcrops; and stratigraphic section measuring where feasible. Coal quality analyses (proximate and some ultimate) were performed on samples collected from outcrops and drill hole cores and cuttings. These analyses along with stratigraphic thickness of coal beds, cross-sections and detailed maps were utilized for entry into the NCRDS. The distribution of coal-bearing rocks, locations of coal mines, and ADGGS field investigations and drilling sites are shown on Plate 1.

Reports on the Northwest Alaska Coal Project written by ADGGS geologists and its subcontractors, and BLM geologists are: Alaska Division of Geological and Geophysical Surveys (1982); Callahan and Eakins (1986) C.C. Hawley and

Associates (1983, 1985); Clough and others (1982a, 1982b); Eakins (1986); Eakins and Clough (1982); Haga (1984); Ramsey and others (1986); Renshaw (1981, 1982, 1983); Retherford (1986); Plangraphics (1983); and Stevens Exploration Management Corporation (1982).

Additional State of Alaska funded products on northwestern Alaska coal are: Arctic Slope Consulting Engineers (1984, 1986); Dames and Moore (1980); Denton and others (1986); and Grinage and Gillen (1986).

Geology, coal bed thickness and coal quality information was also obtained from the following sources: Barnes (1967a, 1967b); Barnes and Hudson (1977); C.C. Hawley and Associates (1977a, 1977b, 1977c); Callahan and Sloan (1978); Cass (1959); Collins (1958); Martin and Callahan (1978); Miller and others (1972); Patton (1967); Patton and Csjetey (1980); Patton and Miller (1968); Patton and others (1968); Rao (1980); Rao and Smith (1983); Sainsbury (1974, 1975); Sainsbury and Hudson (1972); Tailleur (1965); Tailleur and Brosge (1976); and U.S. Bureau of Mines (1979).

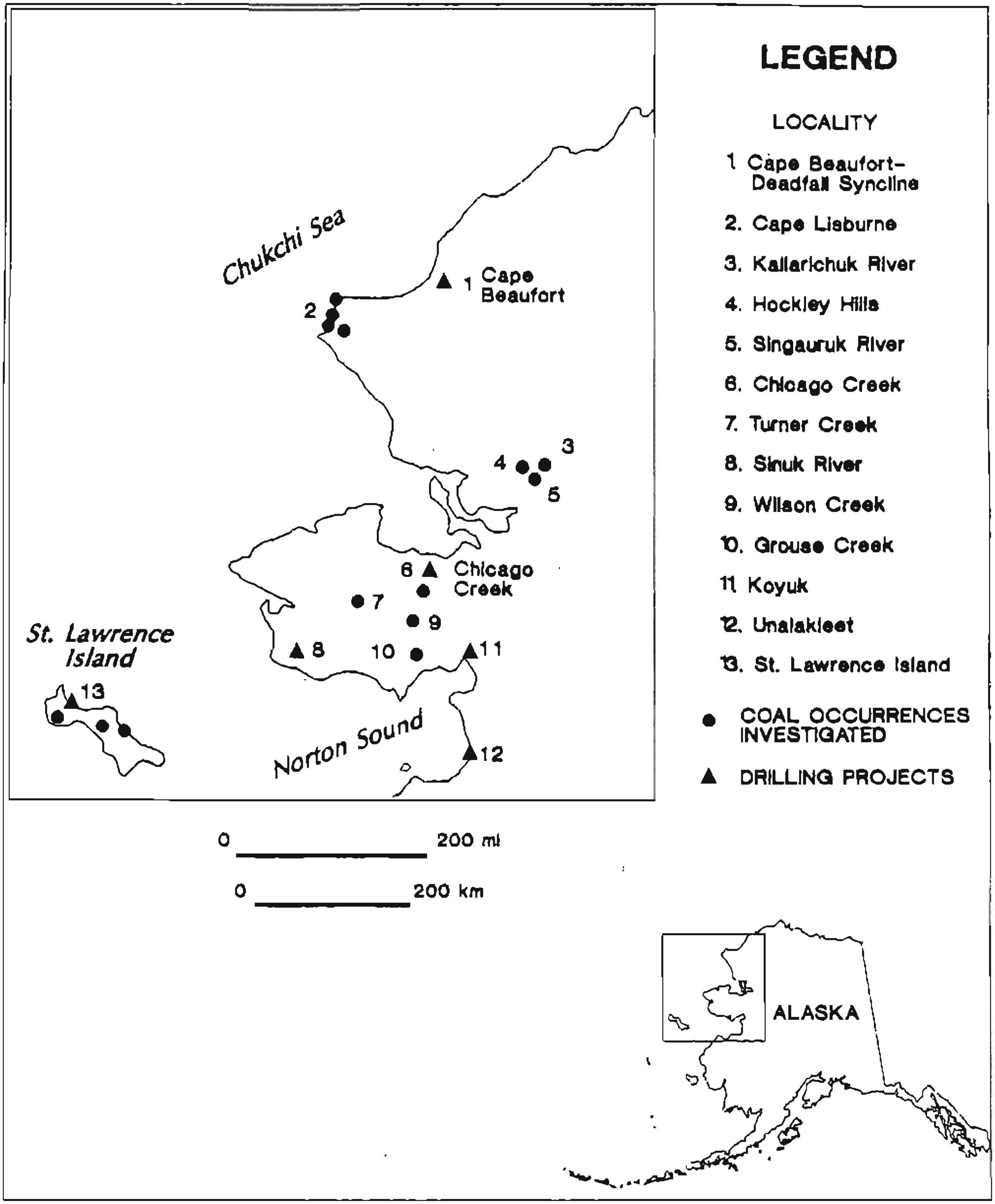

Figure 1. Location map of Northwest Alaska coal localities investigated by Alaska Division of Geological and Geophysical Surveys.

ACKNOWLEDGEMENTS

We gratefully acknowledge the assistance of the U.S. Geological Surveys' National Coal Resource Data System staff in Reston, VA and Denver, CO in our endeavor to incorporate coal resource data from Northwest Alaska into the nation-wide computer NCRDS. William Miller, M. Devereux Carter, Kathleen Krohn, Noreen Rega, Paula Washington, Lewis Boger Jr., and Don Johnson in Reston; and Carol Molnia and Vickie Clark in Denver all contributed their time and effort in our undertaking. Gary Stricker and Ron Affolter, Branch of Alaskan Coal Geology in Denver, provided additional information on Alaska coal along with insight and tips on the NCRDS system.

The 1980-1985 Northwest Alaska Coal Project of the Alaska Division of Geological and Geophysical Surveys was directed by Gil Eakins and U.S. Bureau of Land Management geologists James Callahan, Michael Menge, and Art Banet lent their expertise to the Deadfall Syncline drilling project. Additional field assistance at Cape Lisburne was provided by Larry Lueck and Kathy Goff of ADGGS. Consulting geologists Rob Retherford, Dan Renshaw, Ken Manning, and their respective staff contributed to the acquisition of coal resource data at Chicago Creek, Koyuk, Unalakleet, and St. Lawrence Island and the successful completion of the 1980-1985 project. Conrad Oozeva from Gambell assisted in the drilling and coal explorations on St. Lawrence Island. Numerous individuals from NANA Regional Corporation, Bering Straits Regional Corporation, and the villages and Native corporations of Gambell, Savoonga, Noorvik, Deering, Pt. Hope, Kiana, Unalakleet, and Koyuk were very helpful.

Dr. P. Dharma Rao and Jane Smith of the Mineral Industry Research Laboratory in Fairbanks provided advice on sampling techniques and sample preparation space as well as performing the coal quality analyses.

METHODS

Stratigraphic and coal quality data was compiled from the unpublished results of the 1980-1985 ADGGS Northwest Alaska Coal Project and entered into *Keypunch*, a NCRDS utility software program, on a dedicated microcomputer (PC) to facilitate data entry. Cross-sections of coal deposits, drill hole locations, lithologic and geophysical logs, and measured stratigraphic sections were utilized for data gathering. Additional information was obtained from ADGGS, U.S.

Geological Survey, U.S. Bureau of Mines, and Mineral Industry Research Laboratory (Fairbanks, AK) published and unpublished reports.

Latitude and longitude coordinates for drill hole and outcrop locations were digitized with the U.S. Geological Survey's public domain *GSDIG* software. Stratigraphic and coal quality information was assigned a unique location data point indentification number (Point ID) corresponding to its drill hole number or field geologist's outcrop sample number. This data was submitted on 1.2 mb floppy diskette media to NCRDS staff in Reston, VA where it was converted into USTRAT (stratigraphic) and USALYT (analytical) files within the NCRDS database and storage retrieval system (*PACER*). The Alaska stratigraphic data appears in the AKSTRAT files within NCRDS.

Lithologic logs of drill holes using ADGGS data entered into the USTRAT file system and appearing in the AKSTRAT files were computer generated by U.S. Geological Survey staff in Reston, VA utilizing the NCRDS-available Stratigraphic Analysis Techniques System (*STRATS*) program described by Boger (1986). Seven *STRATS* lithologic log plots were prepared and appear as figures in their respective locality summaries. A table of northwestern Alaska coal data (see appendix) was generated from NCRDS *PACER* files by modem-link to our local microcomputer, edited in Microsoft *Word* (v. 5.0) and merged with this document. This table contains Point IDs, location in latitude and longitude, unit number, *as-received* Btu values, moisture percent, volatile matter percent, carbon percent, ash percent and percentages of H, C, N, O, S and total sulfur Additional tables, *STRATS* logs, and resource estimates utilizing *GARNET* (graphic analysis and resource calculation system) will be created in the future as ADGGS refines its NCRDS capabilities. This information will be incorporated into a final published report.

Coal samples collected during the Northwest Alaska Coal Project were submitted to the Mineral Industry Research Laboratory (MIRL), University of Alaska Fairbanks for proximate and ultimate analyses by ASTM standards.

COAL LOCALITY SUMMARIES

1) CAPE BEAUFORT-DEADFALL SYNCLINE

History and Investigations

Coal in Arctic northwest Alaska was first officially reported by A. Collier, a member of the Beechey expedition to the Arctic Ocean, in 1826-27 (1906, 1908). Coal beds exposed in the sea cliffs at Corwin Bluff, east of Cape Lisburne, were exploited during the late 1800's and early 1900's to replenish the fuel supplies of whaling ships. Coal was also mined from several different beds for use at Nome in 1900-1901. A total of 1,000 tons was produced and shipped during that time. Historic coal prospecting and mining occurred at the sites and mines of Cape Beaufort, Cape Sabine, Thetis Mine, Corwin Bluff, and Corwin Mine (mine no.s 9, 10, 11, 12, and 13 respectively on Plate 1).

In 1983 ADGGS and BLM explored in the Cape Beaufort-Deadfall Syncline region for accurate information on the thickness, continuity, and quality of selected coal beds. This program included auger and core drilling of 21 holes, and downhole geophysics in the Pt. Lay A-2, A-3, A-4, B-1, B-2, B-3 and De Long Mountains D-4 quadrangles. The general geology and drill hole locations are shown in Plates 2, 3 and 4 and Point ID data are shown in the appendix (p. 54-55).

In 1984 coal studies in this region continued by Arctic Slope Consulting Engineers who drilled 47 holes in the Deadfall Syncline area (Arctic Slope Consulting Engineers, 1984). Based on their 1984 drilling program and prior data an assessment of local village utilization of coal was prepared (Arctic Slope Consulting Engineers, 1986).

Geology

Four Cretaceous-age formations occur in the Cape Beaufort - Deadfall Syncline region and are folded and faulted along east-west axes that generally parallel the northern front of the Brooks Range. Intensity of deformation decreases northward from tight, asymmetric folds with steep dips and many faults in the southern part of the foothills belt, to broad open folds with flat dips and few faults under the coastal plain (Barnes, 1967b). The Fortress Mountain, Torok, and Kukpowruk Formations are all primarily of marine origin and mostly barren of coal. The nonmarine Corwin Formation is a clastic sedimentary assemblage of interbedded claystone, siltstone, sandstone, ironstone, conglomerate, minor bentonite and at least 146 coal beds, of which 28 are potentially mineable (Chapman and Sable, 1960). The Corwin Formation is between 11,353 and 15,494 ft thick (Chapman and Sable, 1960) and underlies most of the western North Slope of Alaska beneath Pleistocene and younger surficial deposits. Data from seismic work and three deep exploratory wells suggests that the Corwin Formation can be divided into three informal stratigraphic zones (Callahan and Martin, 1980). Lower zone coal is normally thin and laterally continuous up to 12 mi. Coal of the upper zone is generally thicker, but thins and splits over short distances. Coal beds in the middle transitional zone are 6 to 10 ft thick and laterally persistent for as much as 5 mi (Callahan and Eakins, 1986).

Coal crops out in the sea cliffs at Corwin Bluff (De Long Mountains quadrangle, Plate 4) and in the banks of the Kukpowruk and Kokolik Rivers (Pt. Lay quadrangle, Plates 2 and 3). Deadfall Syncline, east of Cape Beaufort (De Long Mountains quadrangle, Plate 2), is one of many broad structural basins which are separated by complex-faulted and Torok Formation-cored anticlines (Callahan and Eakins, 1986). The Deadfall Syncline contains 8 coal beds ranging from 4.3 ft to 13.1 ft thick. Other prominent synclinal structures include the Kukpowruk, Beaufort, and Howard (Plates 2 and 3), Liz-A, and Thetis Synclines.

In the Liz-A Syncline area, 26 coal beds 1 ft thick or greater have been identified. The majority of these beds are relatively thin or of limited extent. The thickest beds, no. 7 (15-17 ft), no. 8 (12-13 ft), no. 10 (8 ft), and no. 15 (9 ft), contain most of the reserves for the Cape Beaufort area (Dames and Moore, 1980). Dips of between 14° and 20° were determined from drill holes.

At Corwin Bluff, 80 coal beds greater than 1 ft thick, and 17 coal beds between 2.5 and 9 ft thick, have been measured from outcrops (Chapman and Sable, 1960). A sample *STRATS* lithologic log of five drill holes (DH3, DH4, DH5, DH6, and DH11) at Corwin Bluff is shown in Figure 2. Known coal beds in the Thetis Syncline dip from 45° to 52°S near Corwin Bluff, to between 16° and 24°S at the Thetis Mine.

Another important coal occurrence is in Coke basin, a structural depression located along the Kukpowruk River, where 10,000 ft of Corwin Formation is exposed (Chapman and Sable, 1960). Here, beds dip steeply on the flanks of the elliptical basin and flatten abruptly near its center. There are six coal beds ranging from 1 to 3 ft thick, with the thickest coal exhibiting good coking qualities.

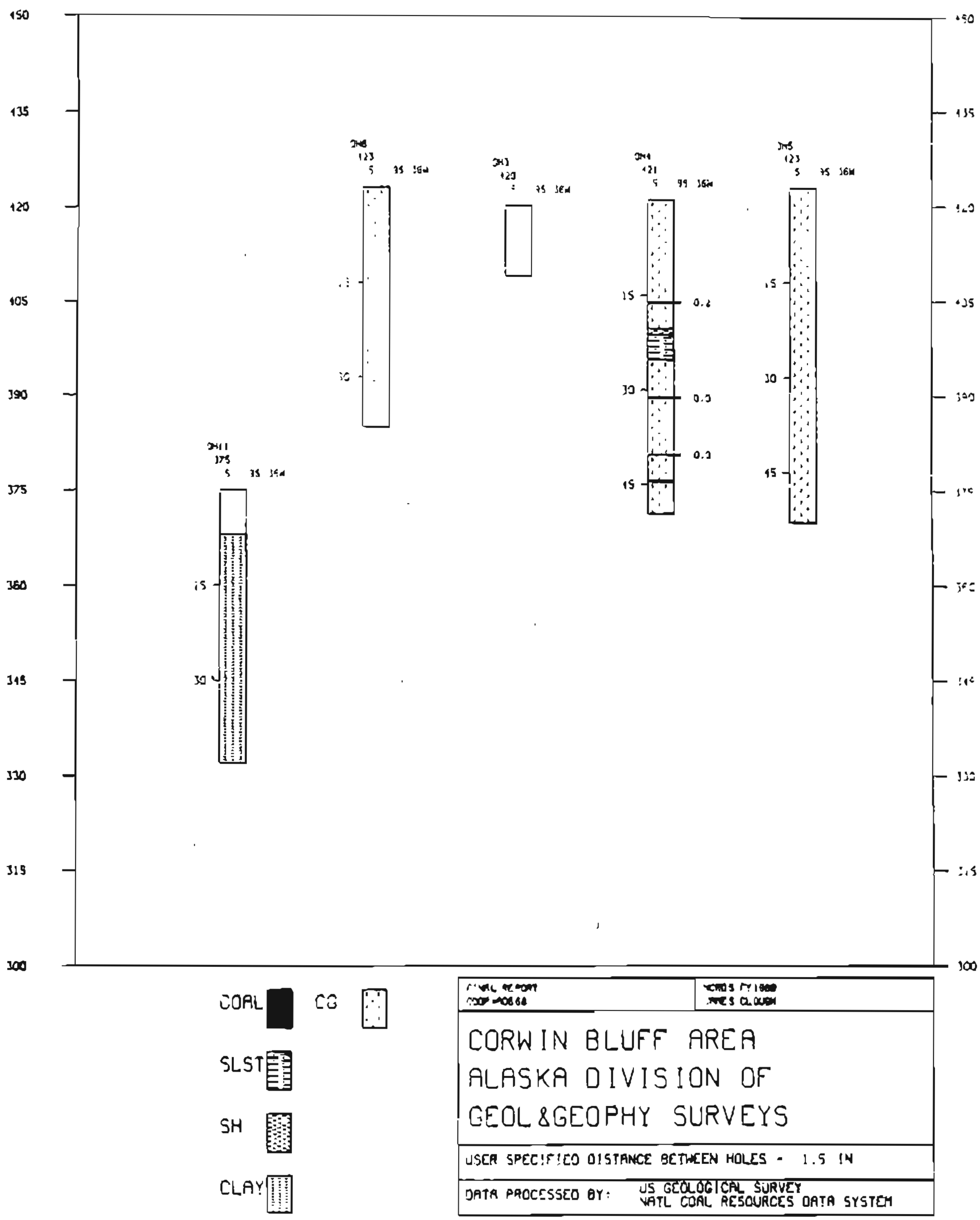

Figure 2. STRATS (Stratigraphic Analysis Techniques System) log for 1983 drill holes (DH) 3,4,5,6, and 11 at Corwin Bluff. Locations of drill holes shown on plate 2.

Coal quality

The Deadfall Syncline contains 8 coal beds ranging from 4.3 to 13.1 ft thick with between 10,675 and 13,209 Btu/lb and are high-volatile bituminous C and B. The coal is low in moisture, ash and sulfur with less than 0.03% pyritic sulfur. The average *as-received* values for the entire Cape Beaufort data set entered into NCRDS are 9,976 Btu/lb, 9.38% moisture, 28.87% volatile matter, 44.55% fixed carbon, 16.73% ash, and 0.27% total sulfur (appendix, p. 55). This average, however, includes coal beds with numerous partings resulting in high ash percentages and corresponding low Btu/lb values. The higher quality coal, excluding ash percentages of >20%, yields average values of 10,598 Btu/lb.

The Coke basin coal has an extremely low *as-received* moisture value of 0.8% and heating value of 15,300 Btu/lb (Warfield and Lauders, 1966; Warfield and Boley, 1969). This coal appears to have been upgraded in rank by tectonic deformation or nearby igneous intrusion.

Coal resources

Onshore combined coal resources for the Cape Beaufort and Deadfall/Liz-A Synclines area are 35,000,000 tons measured, 312,000,000 tons indicated, and 186,000,000 tons inferred (Callahan, 1976). Measured reserves for the Deadfall Syncline, at a 10:1 stripping ratio, total about 15,810,000 tons, with additional reserves of about 59 million tons inferred (Arctic Slope Consulting Engineers, 1984). Coal resources for the Corwin Bluff area show no actual measured tonnages but Barnes (1967) estimates 48,700,000 tons indicated and 848,400,000 tons inferred.

Existing drill hole data indicate that Corwin Formation coals are laterally continuous and resource estimates are reliable where there is no structural complication by faulting. With coal bed dips of 14° to 20° and a projected stripping ratio of 10:1, strip mining of the Cape Beaufort-Deadfall Syncline resources is favored. Steeper dips of 45° to 52° at Corwin Bluff and thrust faulting in the Thetis Mine area suggest that underground mining may be the best coal extraction method at these locations. The potential for mining of Cape Beaufort coal is enhanced by its favorable location at or near tidewater. There are several Coal Prospecting and Preference Right Coal Lease Applications held here (see Plate 3) and Arctic Slope Regional Corporation is currently applying for a Mining Permit in the Deadfall Syncline area.

2) CAPE LISBURNE COAL

History and Investigations

Coal exposed along the coast south of Cape Lewis to below Cape Dyer on the Lisburne Peninsula, was first formally noted in 1831 (Collier, 1906). Whaling ships and revenue cutters for many years replenished their fuel supplies from the readily accessible coal beds visible in the sea cliffs. In 1900 Maddren first recognized that the coals exposed south of Cape Lewis are much older than those elsewhere in Alaska (Tailleur, 1965). Historic coal prospecting and mining occurred at two mines, on the Kukpuk River and at Cape Thompson (mine no.s 14 and 15 respectively on Plate 1). Prior to western contact Inupiat Eskimos from the region collected coal from the beaches for burning with driftwood in campfires.

In 1983 ADGGS investigated the Cape Lisburne coals as potential exploratory drilling sites. Due to observed structural complication the lateral continuity of bedding is highly suspect and it was decided not to drill in this area. Outcrop samples were collected from coal beds for analyses and a panoramic drawing of the bluff south of Kapaloak Creek was prepared by K.M. Goff from photos taken of the sea cliff exposures (Fig. 3).

Geology

Cape Lisburne coal occurs in the Kapaloak Formation, named by Tailleur (1965) for Early Mississippian-age nonmarine sandstone, mudstone, shale, and coal, with minor conglomerate and marine limestone. It lies directly below the base of the Lisburne Group, a sequence of Mississippian-age marine limestone and dolomite.

The structure of the Kapaloak Formation is complex due to extensive faulting, shearing, contorted folding, and crumpling along east-trending fold axes. This results in erratic dip angles ranging from horizontal to vertical. The deformation of the coal-bearing rocks, with their tendency to weather and erode rapidly, has resulted in coal beds that are difficult to locate or trace.

The largest outcrops of Mississippian coal-bearing strata occur in the sea cliffs 1.5 mi south of Cape Lewis and along Kapaloak Creek south of Cape Dyer. Several small beds and a 4-ft sheared coal bed south of Cape Lewis strike N75°E and dip north at 40° (Collier, 1906). In the sea cliffs south of Kapaloak Creek, Tailleur (1965) found 13 coal beds ranging from 2.5 to 11 ft thick., within 2,200 ft of section. The upper 1,900 ft (to the north) of section is coal-bearing but the lower 300 ft is

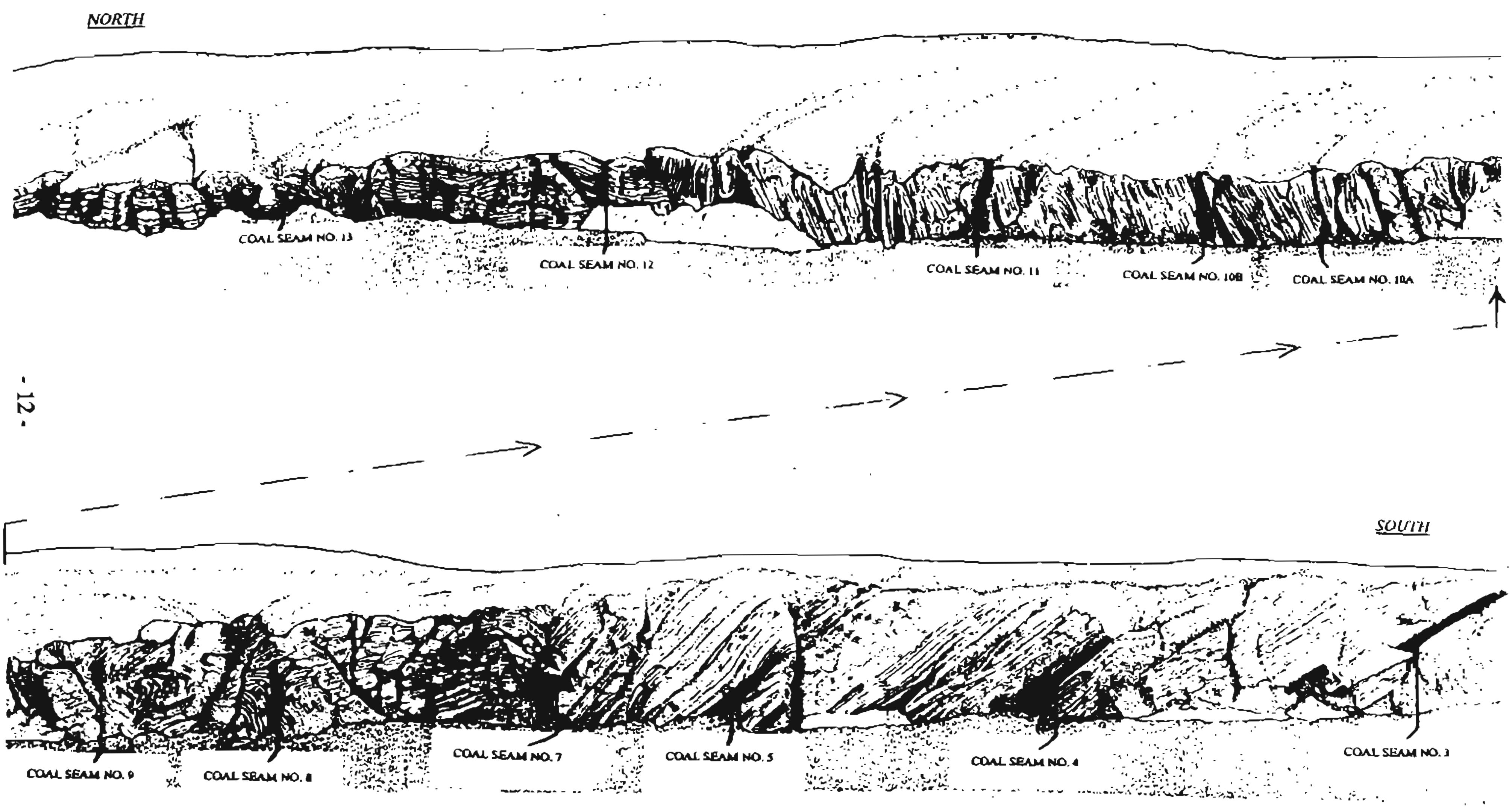

Figure 3. Panoramic drawing of Lisburne Peninsula Cape Dyer coal beds. Drawing by K.M. Goff from photographs.

marine strata and barren. The type section of the Kapaloak Formation at Kapaloak Creek has an overall dip to the south, with moderate to steep attitudes.

Reported isolated occurrences of Mississippian-age coal occur at three additional places: Niak Creek, 5 mi south of Cape Lisburne, where a 4- to 5-ft-thick coal bed dips north at 60° (Collier, 1906); on the Kukpuk River, 0.25 mi west of the mouth of Iglupak Creek, a 6-ft-thick coal bed strikes east and dips 23° to the south (Conwell and Triplehorn, 1976); and at Cape Thompson, 25 mi southeast of Point Hope, where Conwell and Triplehorn (1976) observed two near-vertical beds of coal, each about 1 ft thick.

Coal quality

Samples for proximate analysis were collected by ADGGS from the thickest accessible coal beds exposed in the sea cliffs at Cape Dyer and additional samples in the region were collected from the Kukpuk River area (see appendix). The samples range in *as-received* heating values of 11457 to 14731 Btu/lb with low total sulfur values (appendix, p. 55). The *dry mineral matter free* fixed carbon contents range from 81.8% to 86.02% indicating a rank of low-volatile bituminous to semianthracite.

Coal resources

The lack of continuity of coal beds due to deformation and absence of drill hole data inland prevents accurate reserve estimates of Mississippian coal resources.

3) KALLARICHUK RIVER

History and Investigations

Coal was first discovered in the Kobuk River area in 1884 by Lieutenant G.M. Stoney during exploration work for the Navy Department (Smith, 1913). He reports successfully using bituminous coal from a 2 to 3 ft bed for his steam launch's furnace (Smith, 1913). Lieutenant J.C. Cantwell visited the area later in 1884 but found the coal unsatisfactory for his launch. Mendenhall (1902) also considers this coal to be poor in quality noting it burns slowly and yields abundant ash and disagreeable gases. In 1908, a mine on the Kobuk at its confluence with the Kallarichuk was opened by a Captain Theilen to fuel placer gold operations on nearby Squirrel River. A reported 150 tons was mined at this and several smaller mines nearby during 1918. In 1929, Alexander Haralan reopened the main mine, which became known as the Haralan Mine (mine no. 16, Plate 1), and apparently produced a total of 35 tons of coal during the peak year of 1932. According to an unpublished report by Reed (1931), the Kobuk River Mine (mine no. 17, Plate 1), about 5 mi downstream from the Haralan, also operated during the Squirrel River gold stampede, producing 100 tons of coal that was later lost during spring breakup. Reed (1931) believes that it was from this mine that Stoney and Cantwell obtained coal for their launches. In 1960, Chadwick revisited the area of the two mines and found a number of shallow pits, now caved-in, at the Haralan and piles of coal on the river bank at the Kobuk River Mine (Chadwick, 1960). Patton and Miller (1968) determined the extent of the coal-bearing strata while regional geologic mapping on both sides of the Kobuk River.

From 1979 to 1982, ADGGS explored the Kallarichuk and Kobuk River areas in an unsuccessful effort to relocate the old mine sites and to look for new significant coal occurrences.

Geology

Coal in the Kallarichuk River region (Plate 1) is interbedded with nonmarine Cretaceous conglomerate, sandstone, and mudstone (Patton and Miller, 1968). A potassium-argon age of 83.4 ±2.2 million years obtained from an ash-fall tuff within these rocks agrees with well-preserved Late Cretaceous-age plant fossils in the section (Patton and Miller, 1968). The unnamed Cretaceous nonmarine rocks are found as isolated exposures along the Kobuk River in the Baird Mountains and Selawik quadrangles, with the best exposure at Hotham Peak in the Selawik quadrangle. The regional structure is a broadly folded, NE-trending marginal trough (called the Kobuk/Koyukuk Basin) dissected by numerous high-angle faults (Patton, 1973). Isolated pockets of Cretaceous coal-bearing strata occur in the neighboring Noatak, and Ambler River quadrangles.

At the confluence of the Kallarichuk River, there are numerous coal beds up to 3 ft thick but most seams are much thinner (Dames and Moore, 1980). Eakins (1979) reports the attitude of the beds as striking N60°E and dipping 50° to the south. Two miles down the Kobuk River and 1 mi past the Haralan Mine, Eakins (1979) describes six coal seams ranging from 2 to 18 in. thick, in bedding that strikes N60°E and dips 25° to the south. Five miles further down the Kobuk River a number of poorly exposed thin seams of coal have about the same strike and dip (Eakins, 1979). Chadwick (1960) reported piles of coal here, presumably from the old Kobuk River Mine, but Eakins (1979) and Sanders (1984a, 1984b) found no evidence of the mines. Minor occurrences of coal occur on both forks of the Kallarichuk River. Patton and Miller (1968) report bituminous coal float on the south fork of the Kallarichuk but no coal beds. Clough and others (1982a) describe blocky and relatively unweathered coal float in cutbanks on the south fork of the

Kallarichuk and on a nearby creek. Although coal seams reportedly do occur in the bed of the creek, they were covered by high water at the time of the visit (Clough and others, 1982a). Another small occurrence of coal is located 1 mi upstream from the confluence of the two forks of the Kallarichuk River. Two coal beds 1 ft and 2 ft thick exposed here strike N45°E, dip 45°N., and are of poor quality with high ash content.

Coal quality

Coal quality analyses of two samples from the Kallarichuk River field yield average *as-received* values of 7540 Btu, 15.18% moisture, 27.73% volatile matter, 35.03% fixed carbon, 22.21% ash, and 0.72% total sulfur (appendix, p. 56). Sample 82GE1, which has a heating value of 9292 Btu and an apparent rank of high volatile bituminous C, is similar in quality to the Cretaceous coal at Corwin Bluff and Cape Beaufort.

Coal resources

The absence of drill hole subsurface stratigraphic information and the sparse outcrops of coal in the Kallarichuk River area does not allow for accurate reserve estimates. Additionally, the coal-bearing strata is within and adjacent to the western part of the Kobuk Valley National Park which prevents an extensive exploratory drilling program to determine local structure and lateral continuity of coal. If considerable coal resources exist here their location near the Kobuk and Kallarichuk Rivers makes them readily accessible for development as a local fuel source.

4) HOCKLEY HILLS and 5) SINGAURUK RIVER

History and Investigations

In 1959, Willow Burand (1959) sampled a coal occurrence on the Singauruk River, 16 mi northwest of the village of Selawik, which local natives had for some time been using in their stoves without much success. Chadwick (1960) examined the Singauruk River coal and coal exposed in the northern flank of the Hockley Hills. In 1982 ADGGS geologists located and sampled the occurrences north of the Hockley Hills and on the Singauruk River (Clough and others, 1982b).

In 1907 and 1908 L.S. Quackenbush (1909), on an expedition to collect mammoth fossils for the American Museum of Natural History, discovered minor amounts of coal and peat along Eschscholtz Bay, near Elephant Point, and on the south side of Hotham Inlet. This area was investigated in 1983 by ADGGS and it was determined that exploratory drilling was not feasible due to logistical constraints and lack of evidence for substantial coal resources.

Geology

Cretaceous-age coal in the Hockley Hills and Singauruk River areas (Selawik quadrangle) is interbedded with nonmarine conglomerate, sandstone, and mudstone. These rocks are best exposed at Hotham Peak, where the 3,000 ft of section lacks significant coal beds (Patton and Miller, 1968). The structure of the area is interpreted to be a broadly folded, NE-trending trough (called the Kobuk/Koyukuk Basin) dissected by numerous high angle faults (Patton, 1973). Attitude measurements show that the coal-bearing strata may be near the nose of a regional syncline that plunges 40° to the northwest (Burand, 1959). Isolated pockets of similar Cretaceous coal-bearing strata occur in the neighboring Ambler River and Baird Mountains quadrangles, but whether these rocks are coeval with the Hockley Hills and Singauruk River strata is uncertain. North of the Hockley Hills, beds containing very thin coal layers can be traced across several north-flowing creeks (Dames and Moore, 1980). Clough and others (1982b) describe numerous 1-in. coal streaks in bedding that strike N20°E and dip 40°W. No coal of potential commercial value was found here, but Chadwick (1960) speculates that the coal on the Singauruk River is probably in the same stratigraphic position as the thin streaks at Hockley Hills. Burand (1959) reports that four coal seams at the Singauruk River occurrence range from 2 to 3.5 ft thick, separated by zones of shale, mudstone, and poorly consolidated sandstone. Clough and others (1982) collected a channel sample from the four main beds and report coal thicknesses ranging from 3 to 6 ft with many thin shale partings. Bedding of the coal-bearing strata at this locality strikes N40°E and dips 30°W. Coal may occur in the 3,000 ft of sedimentary section on Hotham Peak, at the extreme western part of the Hockley Hills, (Patton and Miller, 1968), but none has been reported.

Coal in the Elephant Point area is interbedded with up to 500 ft of poorly consolidated conglomerate, sandstone, siltstone and clay with a Tertiary age based on pollen identifications (Patton, 1973). Deposits are confined to small structural or topographic basins, which may be grabens up to 6 mi wide, south of the main Selawik basin. Similar Tertiary coal-bearing strata occur to the south in the Bendeleben and Candle quadrangles. Two Tertiary coal deposits are known to occur in the Selawik quadrangle. On the beach bluffs 2 mi south of Elephant Point in Eschscholtz Bay, a 2-ft-thick coal bed was reported by Quackenbush (1909) but more recently only 4 in. of coal is exposed at low tide (Dames and Moore, 1980). The coal-bearing sequence here is generally flat-lying, with a total onshore extent of only several mi^2 (Dames and Moore, 1980). About 31 mi south of the village of

Selawik up to 500 ft of Tertiary coal-bearing sedimentary rocks are exposed along the east fork of the Mangoak River (Selawik quadrangle). These strata strike NE to NW and dip between N10°W and S30°W (Dames and Moore, 1980). Coal has been found in this area only as float so far, but up to 10,000 ft of Cretaceous through Tertiary coal-bearing section is predicted to occur throughout the Selawik Basin (Patton, 1973).

Coal quality

Clough and others (1982b) assign the low ash coal (82JC3) at Hockley Hills a rank of high volatile bituminous C. The other beds of high ash coal at both Singauruk River and Hockley Hills are subbituminous in rank (analyses given in appendix, p. 56) which is in agreement with Burand (1959) and Chadwick (1960). High ash coal is known to give an apparent rank, when determined from heating values, that is lower than actual rank. Using a float-sink technique to remove the ash, or measuring vitrinite reflectances will yield a more accurate coal rank. Generally, the low ash coal resembles coal beds along the Kobuk River in the Baird Mountains quadrangle, and compare in quality with Cretaceous coal found farther north at Corwin Bluff and Cape Beaufort. No analysis of the Tertiary coal in the in the Elephant Point area was performed because samples were not collected by ADGGS. However, this coal is apparently lignite as described by Quackenbush (1909) and Patton (1973) and appears similar to Tertiary coal found elsewhere on Seward Peninsula.

Coal resources

The favorable location of the coal along the Singauruk River, at an average distance of 16 mi from the villages of Selawik and Kiana, makes future development as a local fuel source a possibility if useful reserves are found. Currently this coal is the demonstrated reserves of Singauruk River coal is difficult to determine due to lack of subsurface information and would be now classified as uneconomical. They are located in the Selawik National Wildlife Refuge but NANA Regional Corporation still retains some selection rights in the area.

36) CHICAGO CREEK

History and Investigations

Coal at Chicago Creek, a tributary to the Kugruk River, (mine no. 18, Plate 1) was discovered by gold prospectors in 1902 (Moffit, 1906), staked in 1905, and mined between 1907 and 1911. During the same period, the Wallin and Superior coal mines (mine no. 19, Plate 1) 6 mi to the south along the Kugruk River, worked what is probably a continuation of the same bed. Coal does not crop out in the area but coal float occurs in the Kugruk River and Chicago Creek. The early gold prospectors located the Chicago Creek coal deposit by looking for traces of coal in the creek bed, upstream from its confluence with the Kugruk River. At Below the point where coal fragments became absent they dug a south-facing adit into the bank at the point where traces of coal were absent. Total coal production of the three mines, approximately 110,000 tons (Toenges and Jolley, 1947), was used by local placer miners at Candle Creek as a source of heat for steam-thaw mining methods. The mine was operated during the winter months and sealed to prevent permafrost thawing around the adit in summer (Ramsey and others, 1986).

From the summer of 1982 through the summer of 1985, contractors for ADGGS conducted extensive investigations of the Chicago Creek deposit. This included field mapping, core and auger drilling, and both down-hole and surface geophysics. Over 60 holes were drilled to a maximum depth of 300 ft (Plate 5) from which 85 samples from cores have been analyzed (see appendix, p. 56-57).

Geology

The Chicago Creek coal field is in a N-S trending linear trough that may be as much as 2 mi wide. Bedding strikes approximately N-S and dips from 50° to 70° W. The coal occurs in one main bed up to 100 ft thick with intermittent partings of sandy or silty clay. The coal rests unconformably on weathered metamorphic schist and is overlain by shale, siltstone and unconsolidated surficial deposits of ice and frozen silt (Ramsey and others, 1986) (Plate 6). Fossil pollen samples obtained from drill hole cores indicates a late Tertiary or younger age of the coal-bearing strata (Haga, 1984). Coal has been traced along strike for 8,000 ft by drilling, both north and south of the original mine site, and is believed to continue for some distance (Stevens Exploration Management Corporation, 1982; C.C. Hawley and Associates, Inc., 1983; 1985; Ramsey and others, 1986). The main bed is truncated by a fault 50 ft south of the old mine adit on the south side of Chicago Creek, but continues with an offset beyond the fault. The coal's irregular thickness implies plastic deformation, which causes pinching out and thickening of the unit at irregular intervals north and south of Chicago Creek. The structural elements at

Chicago Creek trend north-south as a result of eastward-directed compressional forces which were active on a regional scale during the Tertiary (Ramsey and others, 1986). Ramsey and others (1986) suggest this compression warped the strata into anticlinal/synclinal folds which eventually were thrust faulted and subsequently eroded to the present day configuration (Fig. 4).

Downhole stratigraphic data from fifteen Chicago Creek drill holes was processed into four separate *STRATS* lithologic logs (shown in Figs. 5, 6, 7, and 8). Each *STRATS* log represents an E-W transect across the coal deposit and demonstrates the high-angle westerly dip of the main coal bed.

The coal bed mined at the Wallin site is up to 66 ft thick, with several partings of sandy clay and shale; the strike is N15°E, with an average dip of 62°W (Reed, 1933). Coal at the Superior mine has a similar strike and dip, and is reported to be at least 53 ft thick (Reed, 1933). The Superior mining venture was discontinued because the coal bed is truncated by a fault offset on the south side of the mine (Reed, 1933; Dames and Moore, 1980).

Tertiary coal-bearing rocks and coal float have been mapped in the vicinity of French Creek, Goose Creek, Independence Creek, and Mina Creek, all tributaries of the Kugruk River. Although little is known of these coal-bearing rocks, they may be part of the same sequence as those at Chicago Creek (Moffit, 1905; Roehm, 1941; Sainsbury, 1975). Another occurrence of lignite coal, unrelated to Chicago Creek and the Kugruk River, is located on Perry Creek 15 mi west of Chicago Creek. Here, a 2- to 4-ft-thick bed of lignite is overlain by Tertiary to Holocene basalt flows (J.T. Kline, personal communication, 1980). Tertiary coal-bearing rocks may also underlie the Quaternary flats in the upper Pinnell River and Burnt River area (Dames and Moore, 1980).

Coal quality

Proximate analyses of Chicago Creek coal yields an average *as-received* heating value of 6,602 Btu/lb and *dry mineral matter free* fixed carbon contents of 29.22% (appendix, p. 57). This lignite coal contains a significant amount of moisture and fluid bed reactor technology is recommended for combustion (Ramsey and others, 1986).

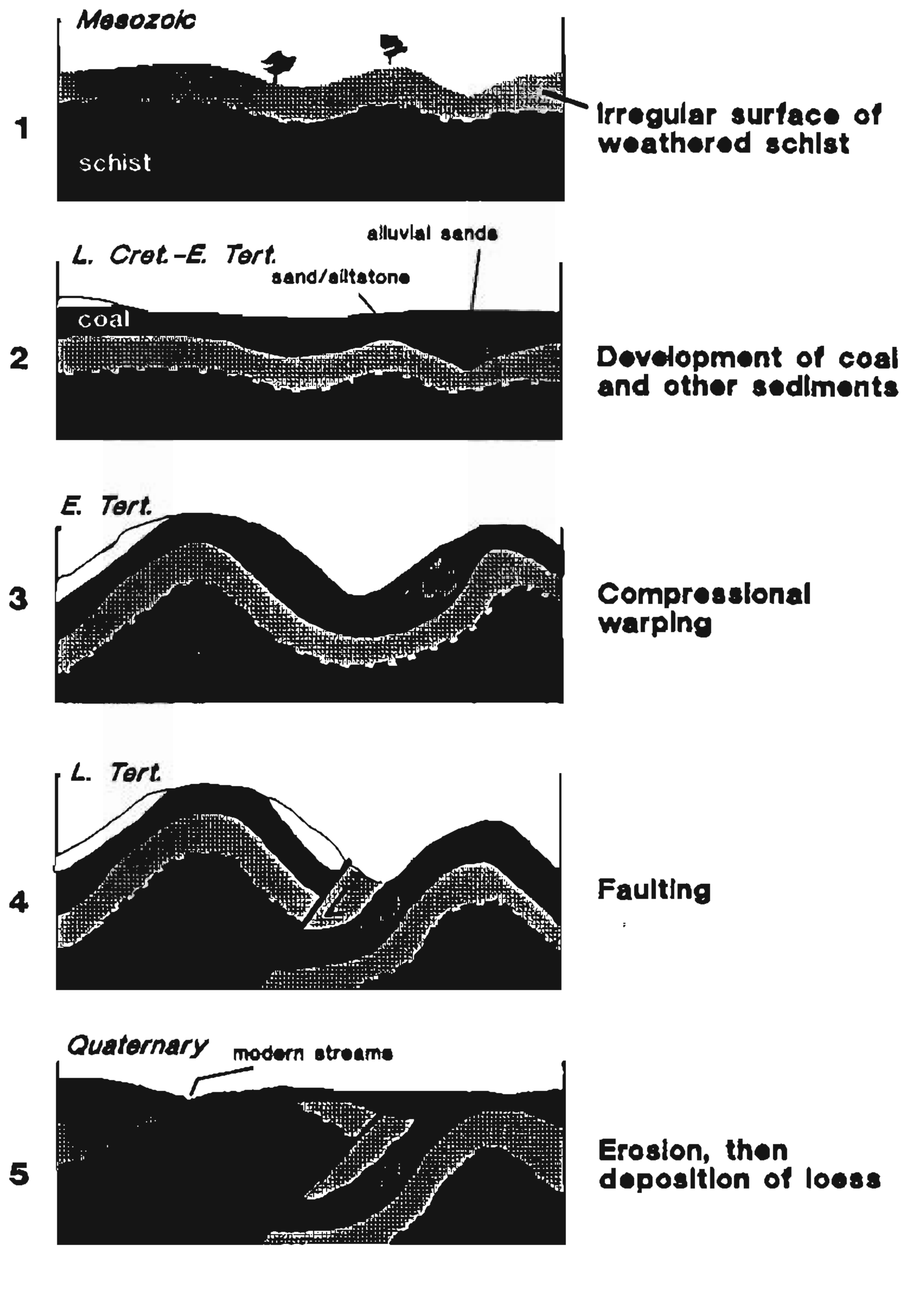

Figure 4. Proposed structural history of the Chicago Creek coal deposit. From Ramsey and others, 1986.

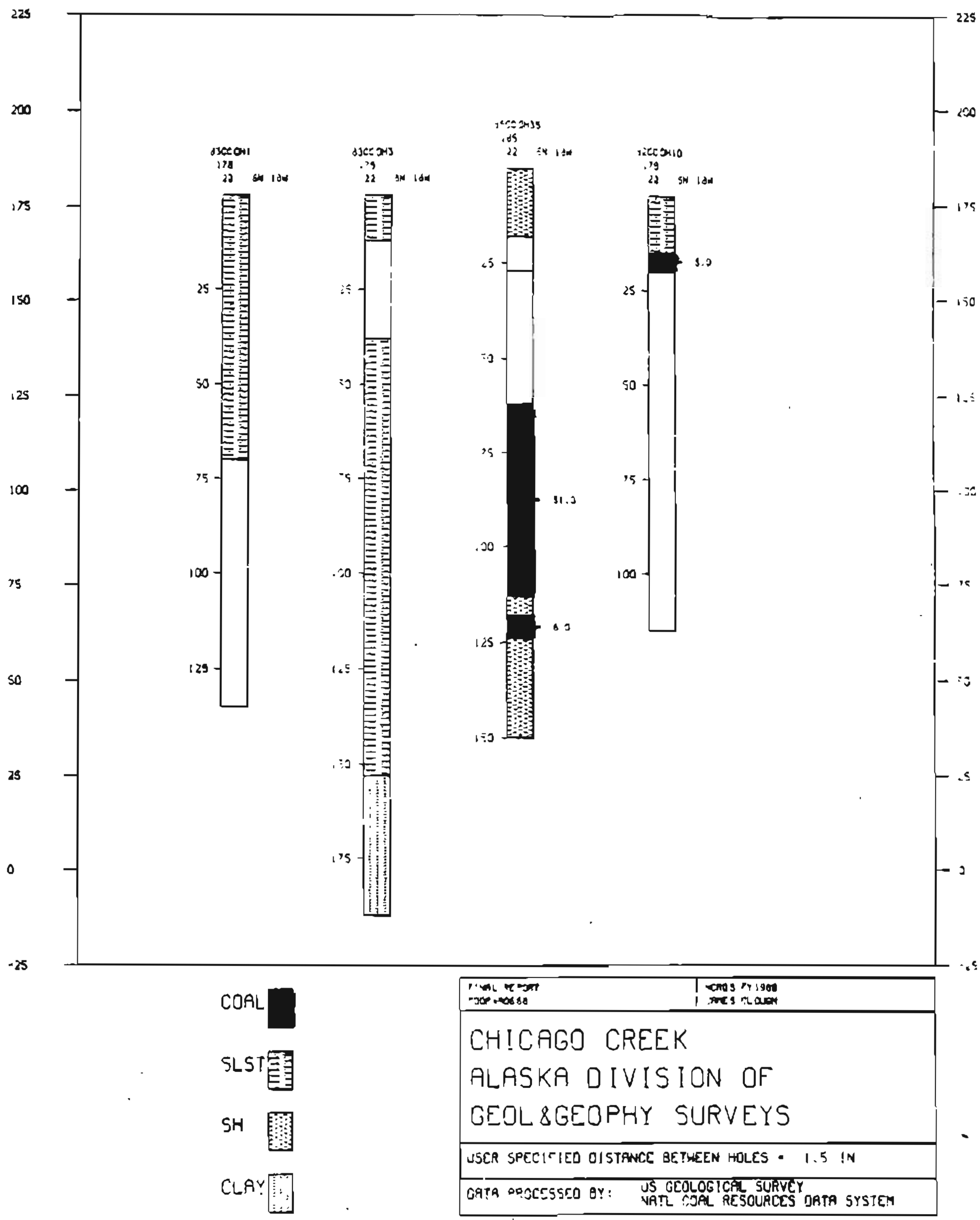

Figure 5. STRATS (Stratigraphic Analysis Techniques System) log for 1982, 1983, and 1985 Chicago Creek drill holes 82CCDH10, 83CCDH1, 83CCDH3, and 85CCDH35.

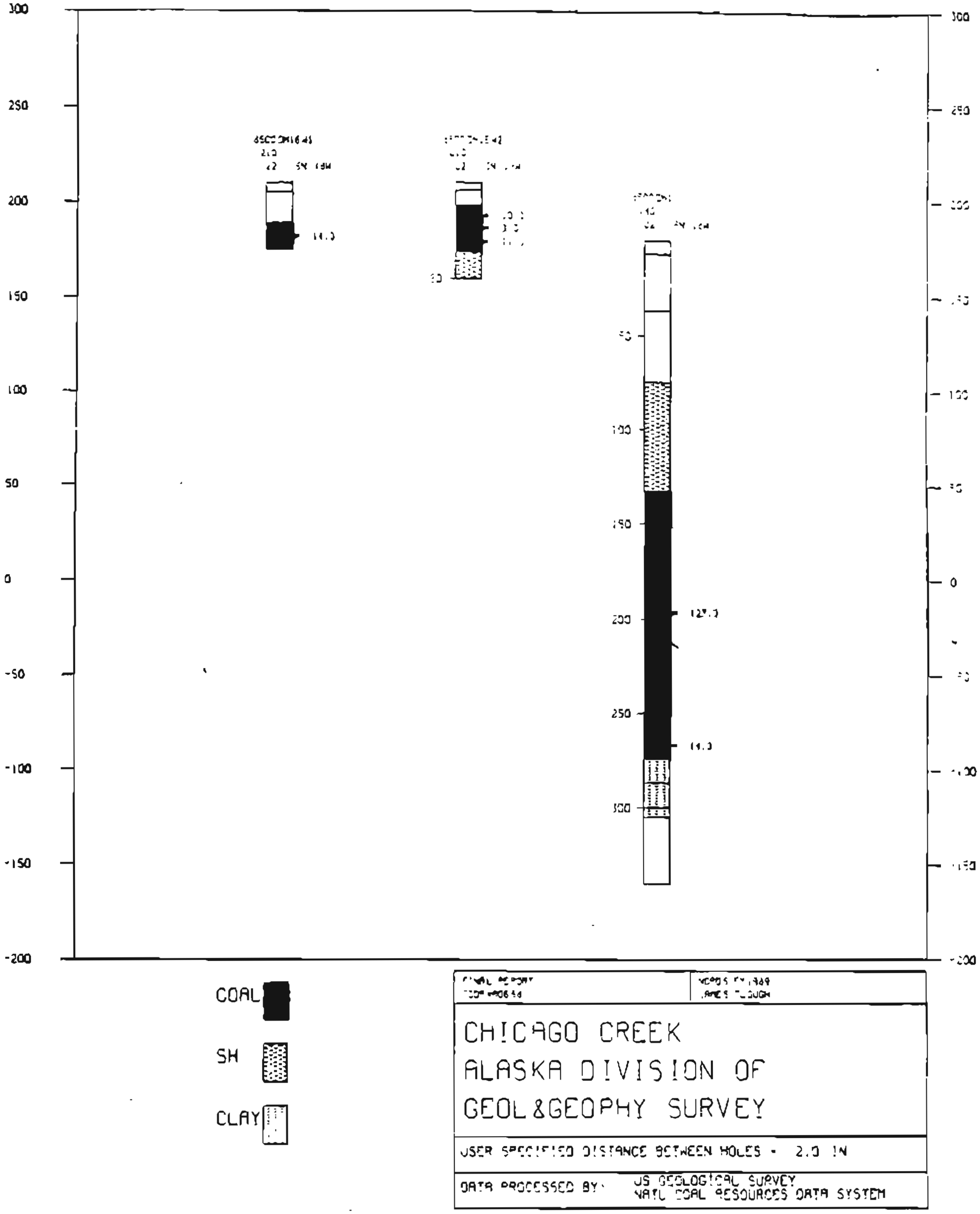

Figure 6. STRATS (Stratigraphic Analysis Techniques System) log for 1985 drill holes 85CCDH1, 85CCDH16W2, and 85CCDH16W1.

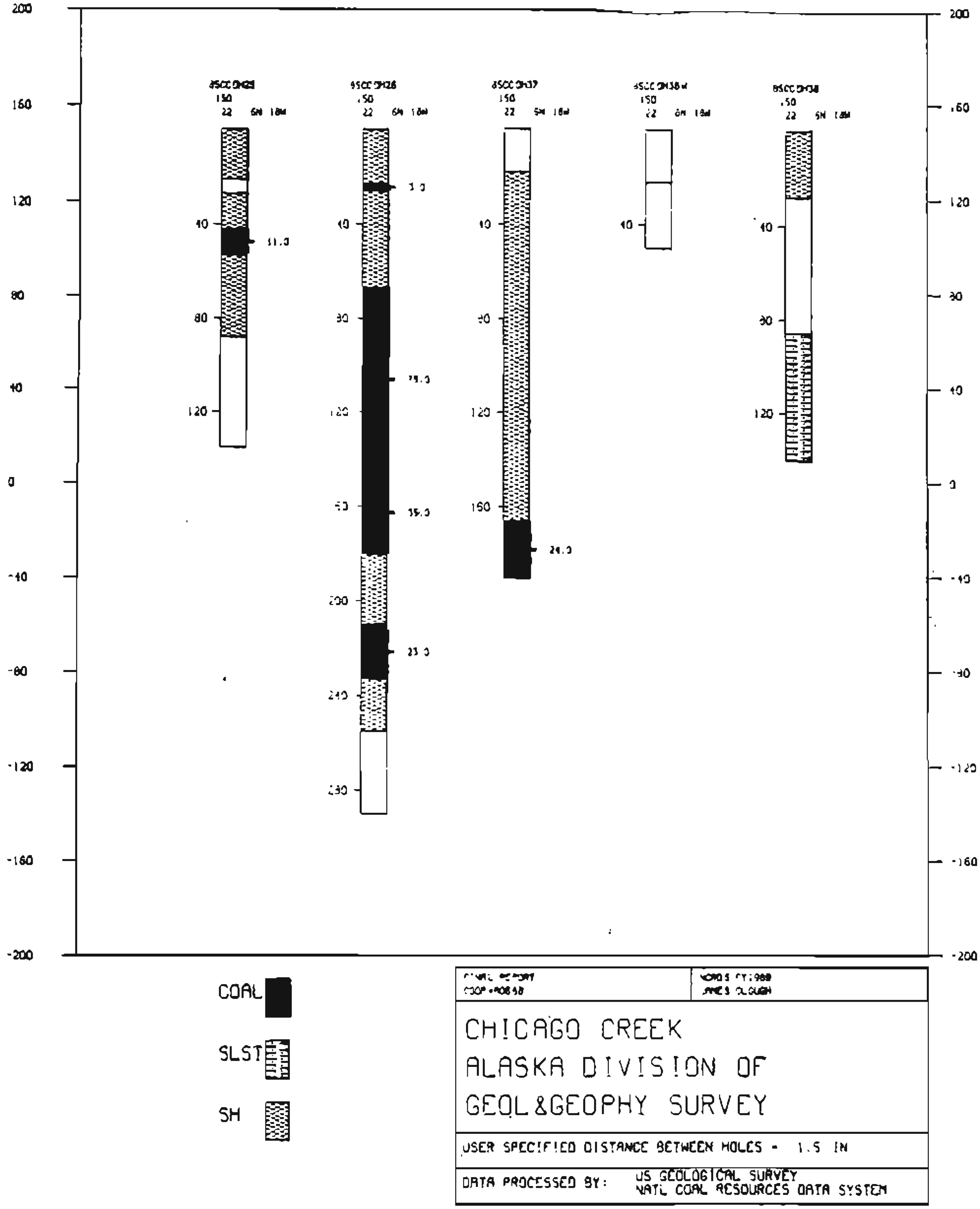

Figure 7. STRATS (Stratigraphic Analysis Techniques System) log for 1985 Chicago Creek drill holes 85CCDH25, 85CCDH26, 85CCDH37, 85CCDH38W, and 85CCDH38.

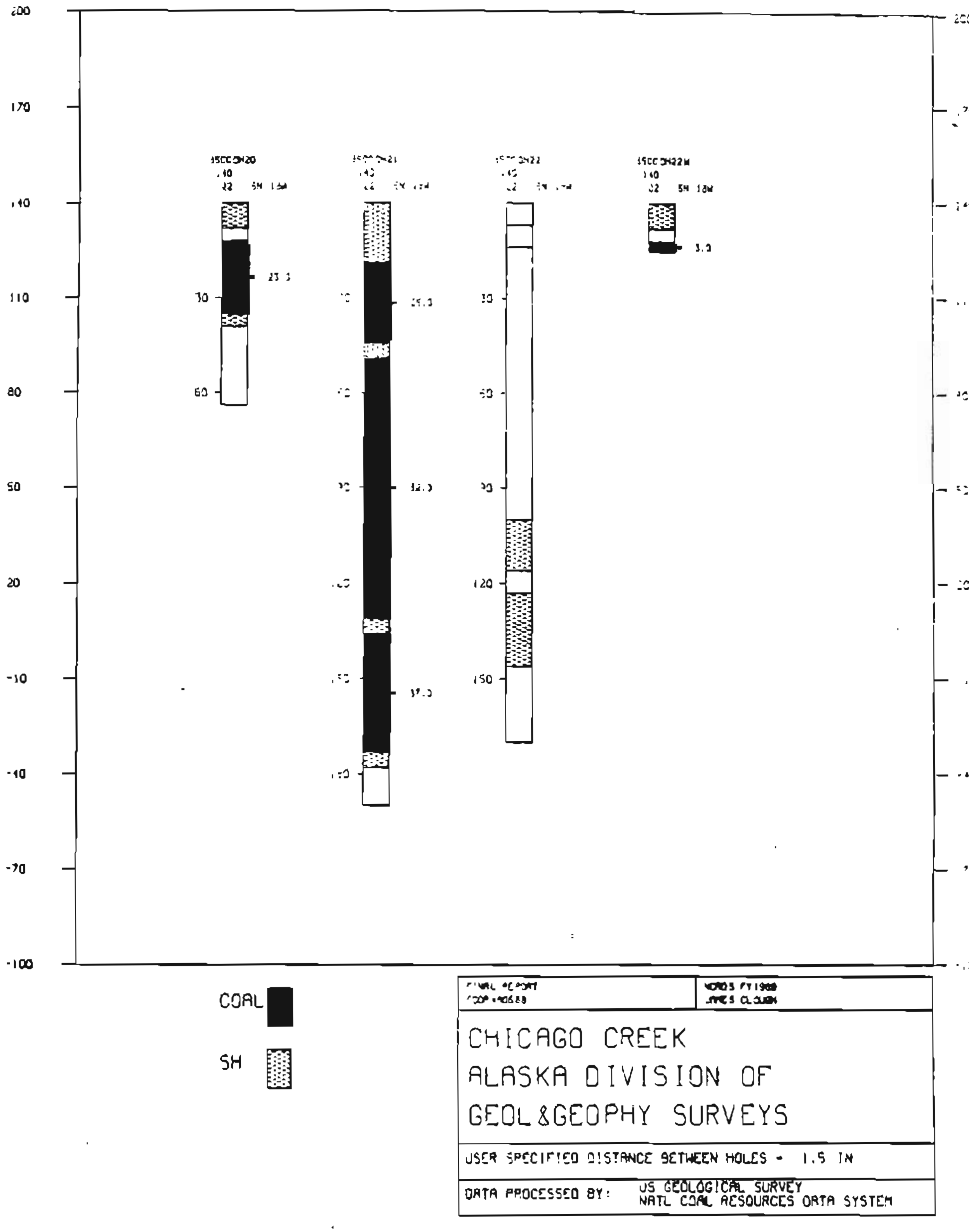

Figure 8. STRATS (Stratigraphic Analysis Techniques System) log for 1985 Chicago Creek Drill holes 85CCDH20, 85CCDH21, 85CCDH22, and 85CCDH22W.

Coal resources

Demonstrated (measured and indicated) coal resources at Chicago Creek total 3.4 million short tons (Ramsey and others, 1986) (table 2). These calculations assume an average lignite coal density of 80 lbs/ft^3. Inferred coal resources based on extension and reasonable continuity of coal beds to the north could add an additional 1 million tons (Ramsey and others, 1986).

TABLE 2

Coal Resource Estimates for Chicago Creek
(from Ramsey and others, 1986, table 2, p. 31)

MINEABLE STRIKE LENGTH	*MINING DEPTH*	*DIP LENGTH*	*DEMONSTRATED COAL RESOURCE (SHORT TONS)*
6,300 ft	100 ft	141 ft	1,140,000
6,300 ft	200 ft	283 ft	2,288,900
6,300 ft	424 ft	424 ft	3,429,000

Retherford and others (1985) developed a preliminary mine plan and feasibility study for the Chicago Creek coal deposit which assumes an average of 50,000 short tons of coal mined per year for 30 years to supply a power plant in Kotzebue. Their study proposes an open pit mine with transportation by truck to Willow Bay and shallow draft barging across Kotzebue Sound to Kotzebue during the short open-water season. The future of coal mining at Chicago Creek is largely dependent on fuel oil prices; as fuel oil becomes more expensive the utilization of lignite coal at Chicago Creek may become feasible.

7) TURNER CREEK

History and Investigations

During the early 1900's lignite was mined from a 1- to 12-ft-thick bed in a pingo on Turner Creek, west of the Noxapaga River in the Bendeleben quadrangle (Hopkins, 1963). In 1982, ADGGS and BLM geologists excavated this bed and sampled it for coal quality analysis (Alaska Division of Geological and Geophysical Surveys, 1982, unpublished).

Geology

Northwest of McCarthy's Marsh along the upper Kuzitrin River drainage, the 250-mi^2 Kuzitrin basin contains Tertiary-age coal-bearing rocks of the Noxapaga Formation which include claystone, sandstone, minor conglomerate, and coal (Dames and Moore, 1980). Outcrops of this formation are found on the northeast bank of Turner Creek and in a pingo west of the Noxapaga River, a major tributary of the Kuzitrin River (Sainsbury, 1975; Dames and Moore, 1980). A gravity anomaly associated with the Kuzitrin basin suggests that the coal-bearing sedimentary rocks may continue to the northeast for considerable distance under Tertiary basalt flows (Barnes and Hudson, 1977; Dames and Moore, 1980).

Coal quality

Analysis of a coal sample from the Turner Creek locality indicates it is lignite with *as-received* heating value of 6,653 Btu and 33.56% moisture (appendix, p. 58). This very low ash (3.46%) lignite is also very low in sulfur (0.16%) but is otherwise similar to Tertiary coal elsewhere on Seward Peninsula.

Coal resources

Coal resources for the Turner Creek area are difficult to determine from two poorly exposed and slumped outcrops since lateral continuity of coal beds is uncertain. The best exposure of coal results from ice wedge growth and subsequent pingo formation which has uplifted the coal bed above the surrounding swamp. The remaining coal resources, if any, lie beneath low tundra and swamp and would be difficult to extract without alterations to the drainage system.

8) SINUK RIVER

History and Investigations

Coal-bearing strata in the Nome quadrangle occur on Coal Creek, a small tributary to the Sinuk River, about 32 mi west of Nome. Natives from the village at the mouth of the Sinuk River first brought the coal to the attention of prospectors in 1902; systematic development of this deposit (mine no. 20, Plate 1) was first attempted in the same year, but no production records remain (Collier, 1908). The mine site today has small-gauge rails leading from a collapsed adit, and rail carts, a boiler, remains of a small cabin and miscellaneous mining items. The first detailed geologic map in the Sinuk River area was compiled by Herreid (1970). In the fall of

1982 ADGGS drilled sixteen exploratory holes at this site (Plate 7) with a tracked vehicle-mounted air drill.

Geology

The Sinuk River area coals are interbedded with well-indurated conglomerate composed of schist, vein quartz, and a few large, well-rounded, slightly-sheared greenstone boulders (Dames and Moore, 1980). Herreid (1970) reports similar coal-bearing conglomerate occurs on nearby Washington Creek and above the gold ore zone on Aurora Creek. In addition to the conglomerates, the coal-bearing rocks contain finer sediments made up largely of decomposed schist pebbles and thin seams of fire clay and coal. Collier (1906) indicates the adit driven into the west bank of Coal Creek across the strike of the coal-bearing strata exposed seventeen seams of coal 3 to 16 in. thick separated by laminae of white fire clay. Only a few thin (< 1 in. thick) seams of carbonaceous shale are visible in outcrop. These clastic units unconformably overlie Paleozoic crystalline limestones and schists (Dames and Moore, 1980), however, the beds are slightly crushed and sheared, and difficult to distinguish from underlying schist bedrock (Collier, 1908). Exposures along Coal Creek are limited by vegetation and deep surficial cover, so that coal-bearing strata are difficult to trace. Collier and others (1908) and Smith (1908) estimate that the coal-bearing strata only extend for about 0.5 mi along the creek and underlie less than a mi^2. Bedding strikes N50°W and dips 18°-30° to the SW (Eakins and Clough, 1982). These coal-bearing units are inferred to be Late Cretaceous or Tertiary in age by Collier and others (1908), while Sainsbury (1975) postulates a strictly Cretaceous age due to their highly deformed character and lack of conglomerate granitic clasts derived from Middle to Late Cretaceous intrusives in the area. Herreid (1970) considers the sediments to be Tertiary and related in origin to the present drainage system. Eakins and Clough (1982) concur with Herreid and describe the deposit as an alluvial fan derived from the regional metamorphic quartz-mica schist.

The sixteen exploratory holes drilled in 1982 by ADGGS (Plate 7) reached total depths ranging from 40 to 77 ft. Very thin beds of carbonaceous shale and possibly coal were encountered in only seven of the sixteen holes drilled in an approximately 0.06 mi^2 area in the vicinity of the mine. Drill hole DH1 located on tundra near the old mine site encountered carbonaceous shale and coal stringers (1 in.-thick or less) at depths of 38 ft, 56 ft, and 65 ft. This hole was terminated in very hard metamorphic schist at 77 ft depth. The rotary air drill cuttings were insufficient for coal quality analyses, often no more than a brief puff of black dust. Downhole stratigraphic data from six Sinuk River drill holes was processed into a *STRATS* lithologic log shown in Figure 9.

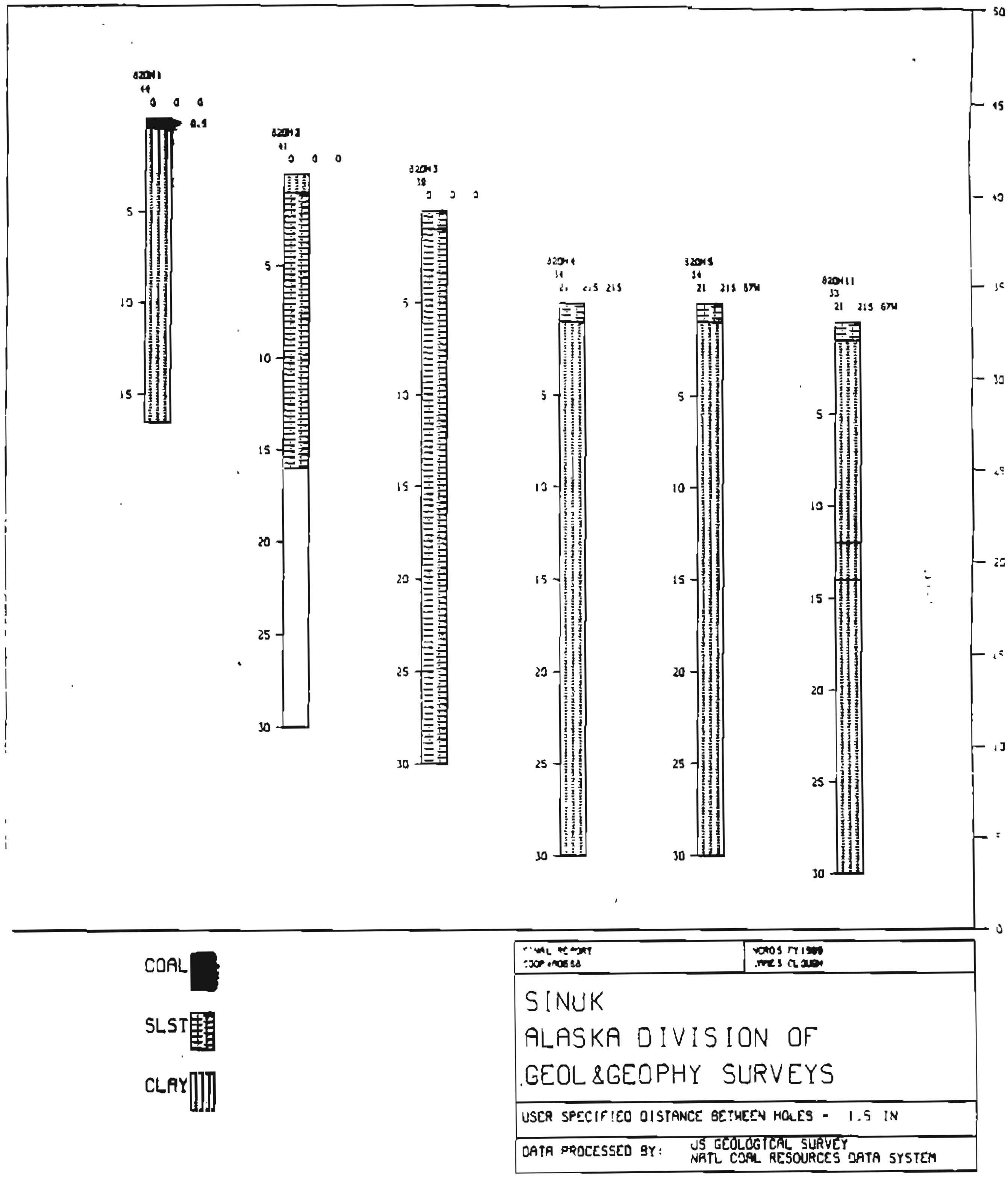

Figure 9. STRATS (Stratigraphic Analysis Techniques System) log for 1982 Sinuk River drill holes 82DH1, 82DH2, 82DH3, 82DH4, 82DH5, and 82DH11.

Coal quality

No samples large enough for laboratory analysis were recovered by drilling, but a weathered coal sample was collected by ADGGS from a pile near the old adit gave an *as-received* ash content of 16.85% and a heating value of 11,311 Btu/lb (appendix, p 58). These values correspond to an apparent rank of subbituminous A or B but they can be considered to be unreliable due to the weathered condition of the sample resulting in low volatile matter (24.51%) and very low moisture (4.07%). No other laboratory proximate analyses have been performed on the Sinuk River area coal. Collier (1908) reports the coal to be bituminous in appearance and that it was used by a blacksmith in Nome for welding purposes which suggests a higher rank than lignite.

Coal resources

Coal in this area is very thin and limited in extent and it appears that the resource was mined out. Detailed geologic study of the coal-bearing strata and additional exploratory drilling may indicate thick and minable coal beds but results of the 1982 ADGGS drilling program are not encouraging. The similar quartz-mica schist congomerate hosted coal as float on Washington and Aurora Creeks reported by Herreid (1970) needs additional investigation, however, in 1982 ADGGS was unable to locate the source beds of the coal float. Coal resources in these areas are probably limited as well.

9) WILSON CREEK

History and Investigations

Coal in the Wilson Creek area (Candle quadrangle) was discovered by early 1900 gold prospectors and first reported by Harrington (1919). In 1980, contractors for the Alaska Power Authority compiled a comprehensive report on the coal resources of northwest Alaska, which includes previously unpublished locations of Tertiary outcrops and coal float discovered in 1978-1979 during uranium and precious metals exploration of the area (Dames and Moore, 1980). In 1982 ADGGS geologists investigated Wilson Creek, a tributary to the Kiwalik River, to ascertain its coal potential.

Geology

Unnamed coal-bearing strata in the Wilson Creek area consist of sandstone, conglomerate, claystone (often containing coalified wood and plant detritus), and coal. The typically flat-lying sediments at Wilson Creek occur at the southeast extremity of the Tertiary-age Kiwalik basin. Large portions of the Kiwalik and adjacent Buckland and Koyuk basins are covered by basalt flows that mask the potential coal-bearing rocks below. Thickness of the Tertiary rocks within these basins is not known, but all three basins are believed to be relatively shallow (Dames and Moore, 1980). Aeromagnetic data produced by ADGGS (Alaska Division of Geological and Geophysical Surveys, 1973), and Bouguer gravity measurements published by the USGS (Barnes and Hudson, 1977) help to define the Kiwalik and Buckland basins. The linear shape of the basins suggests that they are fault controlled, while the structure of the Koyuk basin is not known (Dames and Moore, 1980). In the Kiwalik basin, the coal-bearing sedimentary rocks are thickest near the Kiwalik River, which probably marks the axis of the basin. The basalts covering much of this basin are thickest in the northern and southern portions, and thin to absent near its center (Barnes and Hudson, 1977; Dames and Moore, 1980). The eastern and western boundaries of the Kiwalik basin are defined by contacts with older metamorphic and igneous rocks. The coal-bearing units in the Wilson Creek area closely resemble Miocene rocks in the adjacent Bendeleben quadrangle and are tentatively assumed to be Tertiary in age or younger (Harrington, 1919; Dames and Moore, 1980).

The coal and clay at Wilson Creek are badly slumped but partly exposed for 20 to 30 ft along the creek bank and are overlain by basalt. When examined by Resource Associates of Alaska geologists in 1978, only 3 ft of the coal bed was visible, but it is believed that the total thickness could be as much as 10 ft (Fankhauser and others, 1978). Coal rubble along the creek indicates that the coal may extend under the surface for an additional 600 ft or more downstream from the outcrop.

Additional coal float and outcrops of Tertiary sedimentary rocks are found on Coal Creek, Connolly Creek, Hunter Creek, and Lava Creek, all tributaries of the Kiwalik River on the eastern perimeter of the basin (Dames and Moore, 1980).

Coal quality

A sample of lignite coal (82GE7A) collected as float from along Wilson Creek (the coal bed was not exposed in 1982 due to slumping and thick snow cover) yielded an *as-received* heating value of 6445 Btu (appendix, p. 58). This is only 1 Btu higher in heating value than the Grouse Creek weathered coal samples.

Coal resources

At present the quantity of coal in this area is unknown but may hold potential for considerable tonnages of Tertiary lignite coal (Dames and Moore, 1980). The association of coal in the Wilson Creek area with a basalt flow suggests that it may have been deposited in a similar setting to the Grouse Creek area coal described below. Further evaluation will require drilling and trenching, however, the locality is a considerable distance from tidewater (>30 mi) and potential local users.

10) GROUSE CREEK

History and Investigations

In the Death Valley area of Seward Peninsula coal as float along the Tubutulik River was first recognized by Mendenhall (1902) and the presence of a Tertiary-age coal outcrop on Grouse Creek (Plate 1) was first described by West (1948). Additional geologic reports on the area include Miller and others (1972) and Sainsbury (1974).

In 1980, a sedimentary uranium drilling program conducted by Houston International Minerals Corporation revealed that a significant deposit of coal exists in Death Valley (Dickinson and others, 1987). Fifty-two holes drilled along a 3,500-ft north-west trending mineralized zone indicate the presence of a 175-ft-thick coal bed. This property was conveyed to Greatland Exploration, Ltd. in 1982 and the data, although published in part by Dickinson and others (1987) and Dickinson (1988), remains proprietary and unavailable to ADGGS at present.

Geology

East of the Darby Mountains, in the Bendeleben A-1 quadrangle, quartz monzonite plutonic with Tertiary volcanic and sedimentary rocks occur in the Death Valley basin. Coal occurs as float along the Tubutulik River, as coal fragments in the sands underlying the basalt flows, and in Tertiary outcrops along the eastern margin of the basin (Resource Associates of Alaska, 1978). Sedimentary rock exposures are rare as Eocene to Holocene black aphanitic basalt flows cover much of its southern extension. This southern extension of the Death Valley basin was named the Boulder Creek basin by industry geologists (Dickinson and others, 1987). The Boulder Creek basin sediments and volcanics were deposited in a graben which formed in the north-south Kugruk fault zone, described by Till and others (1986), and is probably related to the Chicago Creek deposit in tectonic setting.

An approximately 35-ft-thick coal outcrop on Grouse Creek (Fig. 10) is highly weathered and slumped with bedding attitude indiscernible. We believe this coal is coeval with and probably the same bed as the thick subsurface coal discovered by Houston Industrial Minerals Corporation. According to their drill logs, the 175-ft-thick lignite coal lens encountered in drill hole DV-30 contains minor partings and is overlain succesively by: an Eocene basalt flow, coal, lacustrine sideritic mudstone, sandstone and a Quaternary basalt flow (Figs. 11 and 12) (Dickinson and others, 1987). Depth to the thickest coal bed is 300 ft with other coal intercepts as shallow as 70 ft (Hederley-Smith, D., personal correspondence, 1985). The coal and uranium are hosted in Paleocene nonmarine sandstone with average uranium grade of 0.27% U_3O_8 (Dickinson and Cunningham, 1984). The coal and related sedimentary rocks were deposited in the area of ancestral Lake Tubutulik, created when early Eocene basaltic lava dammed the ancestral Tubutulik River and flooded the valley (Dickinson, 1988).

West of Death Valley is McCarthy's Marsh, a present-day topographic depression, containing 3,000 to 10,000 ft of Tertiary sedimentary fill based on gravity measurements (Barnes and Hudson, 1977). This basin is fault-bounded to the north and east by the Bendeleben and Darby Mountains. Coal float with a woody, lignitic appearance, and sedimentary rocks typical of the Tertiary coal-bearing strata in Death Valley, have been found on Omilak, Windy, and Telephone Creeks (Resource Associates of Alaska, 1978).

Coal quality

The average of two proximate analyses of Death Valley coal samples recovered from the sedimentary uranium drilling program yield *as-received* 3.3% ash, 0.52% total sulfur. and a Btu value of 7,680 (Stricker, G., 1986, oral communication). This data will be entered into NCRDS as soon as it is released. The two highly weathered samples (82GE6A and 6B) collected from the outcrop on Grouse Creek are lignite in rank with an average *as-received* heating value of 6444 Btu (see appendix, p. 58).

Coal resources

The presence of a 175-ft-thick coal bed indicates considerable coal resources exist in Death Valley. When the drill hole coal intercept data is released ADGGS will calculate coal reserves. The lateral extent of the Grouse Creek coal exposure is unclear due to slumping of the overburden and reserve estimates based on this outcrop would be unreliable. The presence of basalt overburden, considerable depth to subsurface coal beds (up to 300 ft), and distance from tidewater (>25 mi)

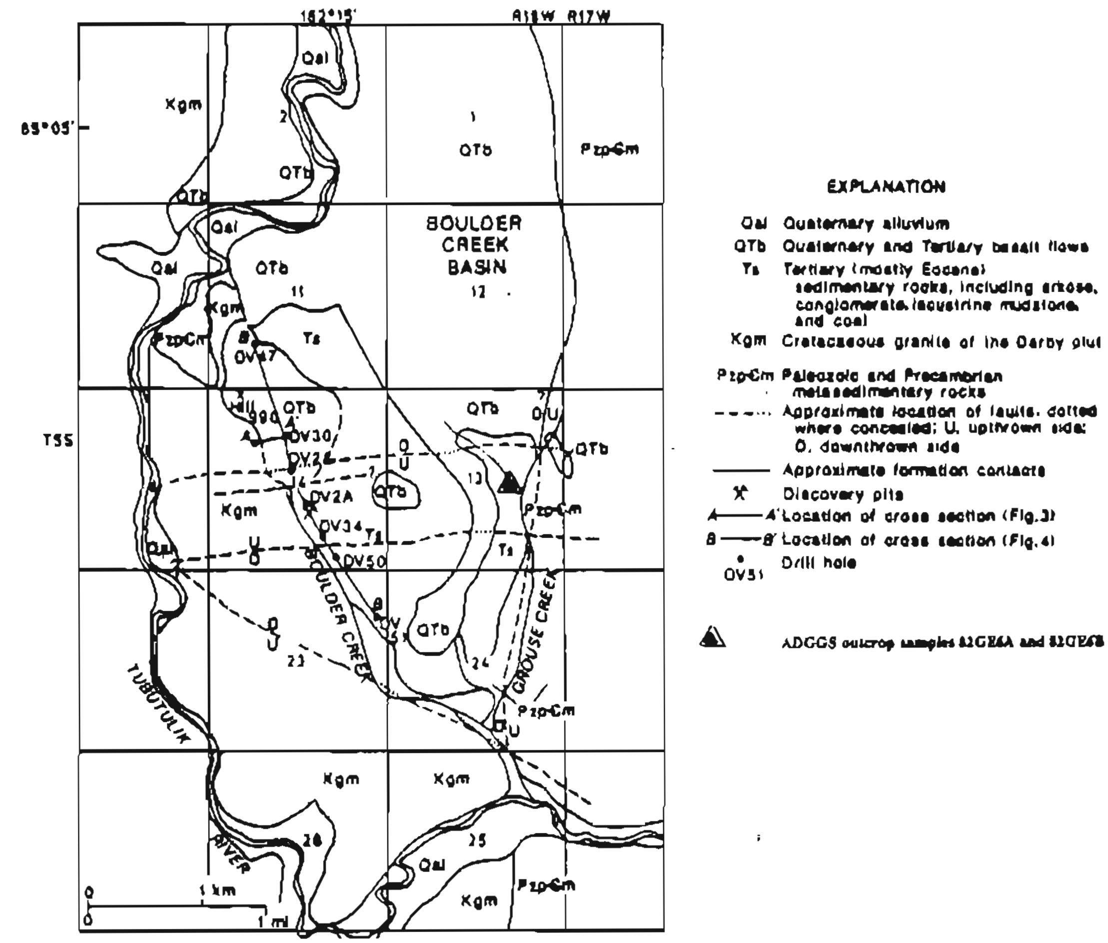

Figure 10. Geologic map of the Death Valley uranium and coal deposit. From Dickinson and others, 1987; p. 1561.

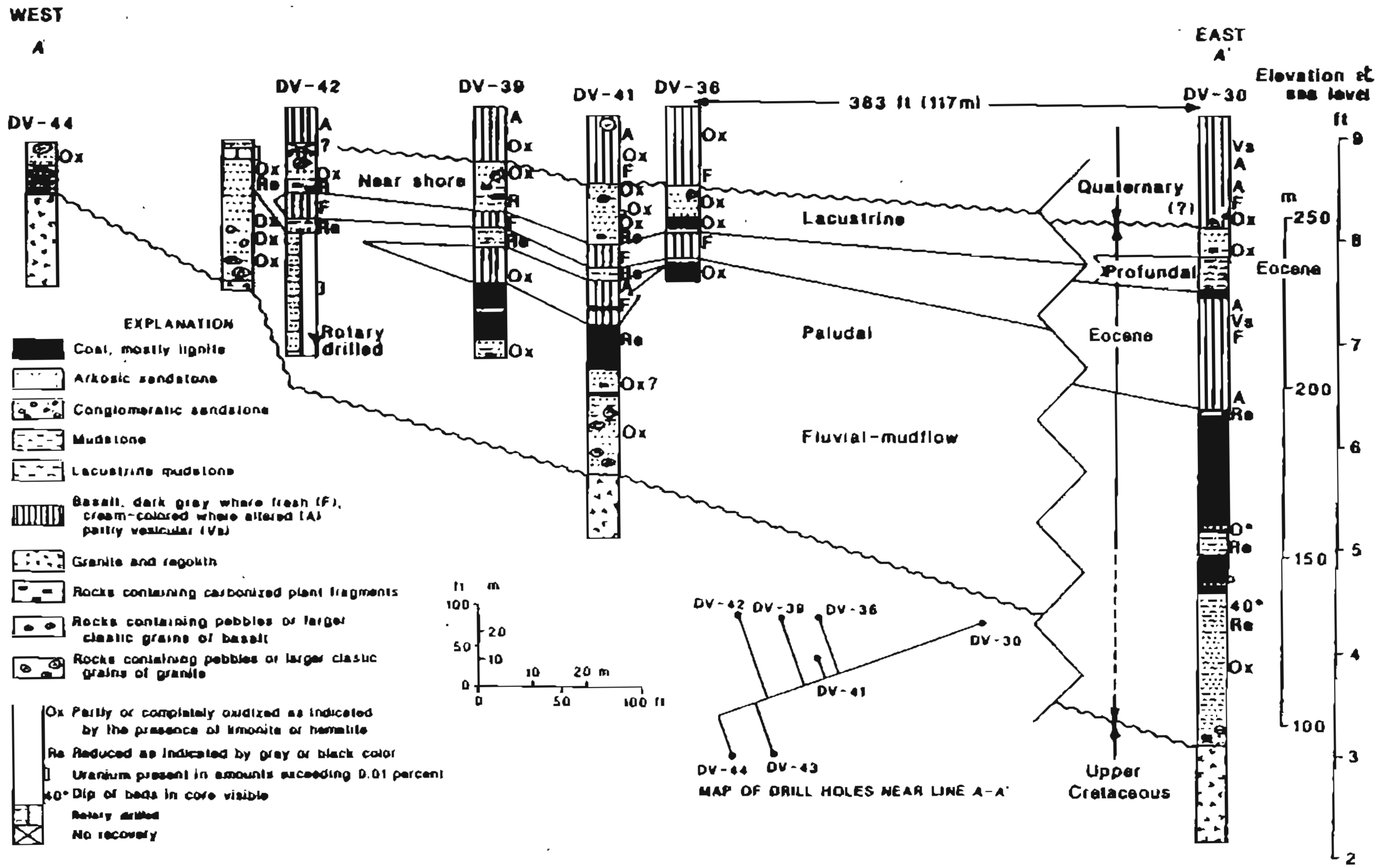

Figure 11. Line of drill hole-based lithologic sections (A-A', Fig. 10) in Death Valley uranium and coal deposit. From Dickinson and others (1987, p. 1563).

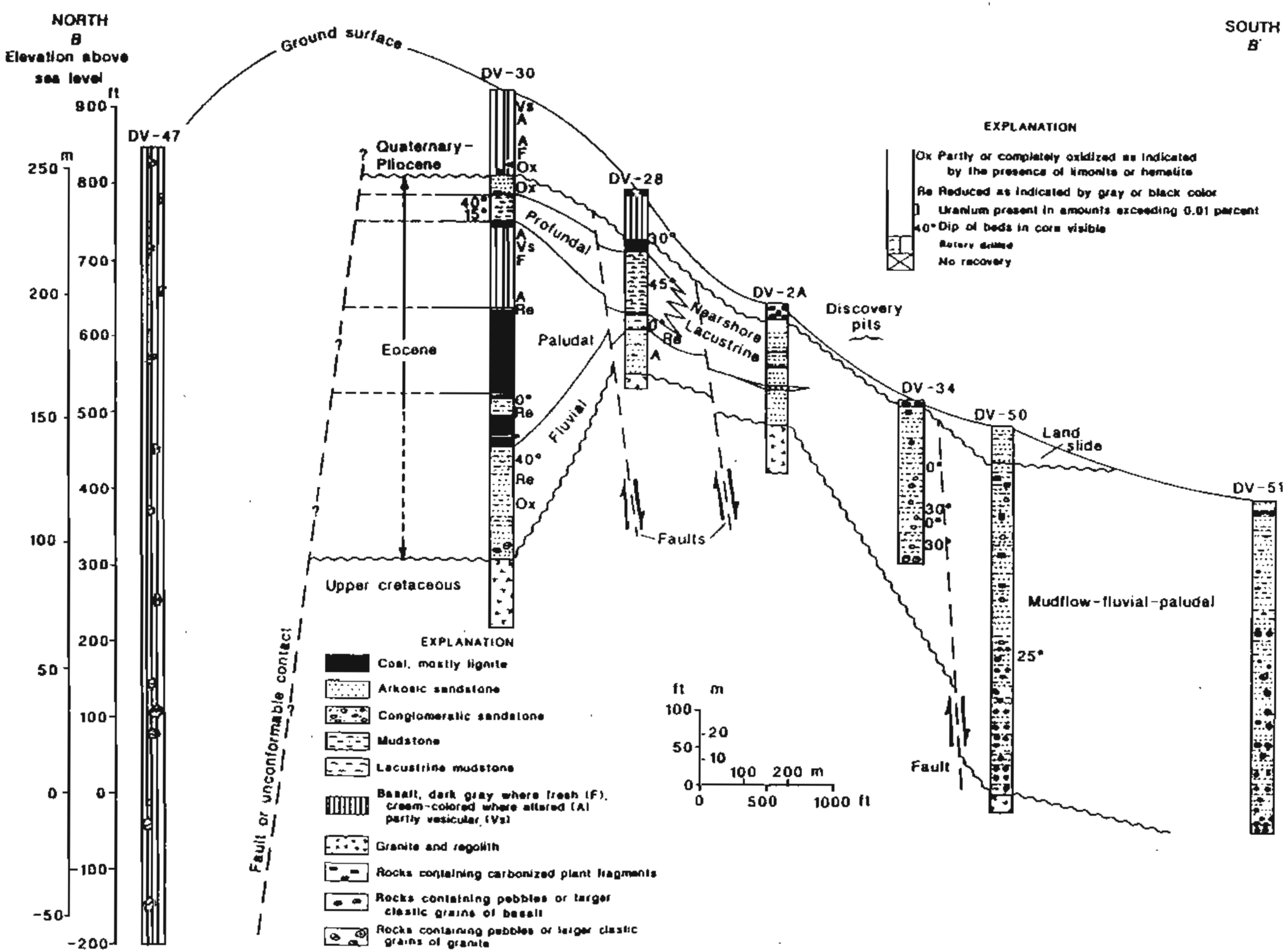

Figure 12. Line of drill hole-based lithologic sections (B-B', Fig. 10) in Death Valley uranium and coal deposit. From Dickinson and others (1987, p. 1564).

is not favorable for development of Death Valley coal. The deep sedimentary basin beneath McCarthy's Marsh may also contain quantities of coal comparable to the Death Valley deposit (Resource Associates of Alaska, 1978).

11) KOYUK

History and Investigations

For years, residents of the Koyuk area have picked up coal on the beaches of Norton Bay for fuel, and barges have hauled up coal from the bottom of the bay when weighing anchor (Stevens Exploration Management Corporation, 1982; C.C. Hawley and Associates, 1983). Coal was first prospected in the Koyuk area sometime before 1909. The coal claims were located on a creek locally called 'Coal Creek' (mine no. 21, Plate 1), a tributary of the Koyuk River, and Harrington (1919) reports that a coal mining permit was issued in 1919 for an unspecified location on the Koyuk River.

The vicinity was visited by geologists Smith and Eakin in 1909. Their examination of the abandoned prospect sites failed to reveal any coal beds. The sedimentary rocks exposed in old prospect shafts were reportedly much less indurated than those of the Kaltag and Nulato formations to the east (Smith and Eakin, 1910; 1911). This suggests that the Koyuk coal-bearing rocks are Tertiary rather than Cretaceous in age. Harrington (1919) recorded secondhand reports of a 2- to 4-ft-thick coal bed and some thin seams exposed at sea level near the mouth of the Koyuk River, but they have not been observed by later investigations (including those conducted by ADGGS). Regional scale geologic mapping by Cass (1959), Patton (1973), and Hudson (1977), has not clearly identified the age and extent of the coal-bearing strata.

In 1982-83 ADGGS explored for coal in the Koyuk area by rotary drilling. An ADGGS' subcontractor drilled twenty-two holes along the Koyuk River in 1982 and in 1983 a second subcontractor undertook a program of geophysical and surface mapping, and drilled an additional twelve holes on approximately 230 acres near the mouth of the Koyuk River.

Geology

The unnamed coal-bearing sequence in the lower Koyuk River area may be Late Cretaceous in age, possibly related to the Shaktoolik Group (including the Kaltag and Nulato Formations) or to the Ungalik Conglomerate (Cass, 1959; Patton, 1973), or may be of Tertiary age, contemporary with the Koyuk basin coal-bearing group to the north in the Candle quadrangle (Stevens Exploration Management Corporation, 1982; C.C. Hawley and Associates, Inc., 1983, 1984). To the east, these rocks are believed to be more continuous, although blanketed by thick alluvium, and may continue northward along the Koyuk River for as much as 30 mi (Harrington, 1919; Hudson, 1977; Dames and Moore, 1980). The coal-bearing strata are bounded on the west by older metamorphic rocks, and on the north by rolling hills composed mostly of volcanic rocks.

The coal-bearing sequence near Koyuk dips 10°- to 20°S, with a strike of N70°-85°E. Typical coal-bearing strata are thin, low-angle cross-bedded, unconsolidated silts and sands, containing clay laminae and scattered coaly material. The coal occurs in irregularly shaped lenses rather than in continuous beds (Stevens Exploration Management Corporation, 1982; C.C. Hawley and Associates, 1983).

The 1982 ADGGS drill holes reached an average depth of 20 ft with ten penetrating coal up to 3.5 ft thick. Thirteen holes drilled in 1983 logged a cumulative total of 1,442 ft, intercepting coal that proved to be thin and discontinuous (Plate 8). Of 10 coal intercepts, all at different horizons, the thickest was 3.5 ft, and most were less than 1.5 ft thick (C.C. Hawley and Associates, 1983).

Coal quality

Average *as-received* values of the Koyuk coals are: 8,365 Btu/lb, 21.77% moisture, 29.42% volatile matter, 39.78% fixed carbon, 9.22% ash, and 0.38% total sulfur (appendix, p. 58). This includes average analyses of samples from 16 drill hole combined with a beach-level outcrop weathered sample (82GE7B). There is no apparent difference in the values obtained from drill hole and outcrop samples as shown in the appendix. The coals rank as subbituminous C to subbituminous B, and are typical of Tertiary-age subbituminous coals found elsewhere in northwestern Alaska.

Coal resources

The discontinuous nature of the coal, discovered during the 1982 and 1983 drilling programs, makes quantitative coal-resource calculation unrealistic (Stevens Exploration Management Corporation, 1982; C.C. Hawley and Associates, 1983). The coal is interpreted as deposited in an ancient river delta distributary system. This environment of deposition does not promote thick, continuous coal bed formation. Judged solely on drilling results, the coal resource potential in the Koyuk area is not high. However, abundant, widespread coal float and other indirect indications of coal in the Koyuk region suggest the possible presence of undiscovered coal resources exist beneath the surficial sedimentary cover (Stevens Exploration Management Corporation, 1982; C.C. Hawley and Associates, 1983).

12) UNALAKLEET

History and Investigations

Coal was mined in the early 1900's from a timber-supported adit dug at beach level into the bluff south of the village of Unalakleet (Cathcart, 1920). Cathcart (1920) reports that 300 tons of weathered coal from this Norton Sound beach mine (mine no. 26, Plate 1) was sent to Nome and St. Michael in 1918 for steamship use. A nearby creek is now named Coal Mine Creek.

Early geologic studies in the region include reports by Smith and Eakin (1911) and Harrington (1919), and the first comprehensive geologic map was published by Cass (1959).

In 1982 ADGGS, BLM, and Stevens Exploration Management Corporation geologists conducted a brief reconnaissance of the Unalakleet coal occurrences. In 1983 C.C. Hawley and Associates drilled 12 rotary bore holes along the coast at the top of the bluff adjacent to exposed coal (Ramsey and others, 1986).

Geology

The eastern coast of Norton Sound is characterized by a thick and extensive sequence of nonmarine and volcanogenic Cretaceous to Tertiary sedimentary rocks (Ramsey and others, 1986). These rocks, mainly greywacke, mudstone, sandstone and coal, are probably equivalent to the Kaltag and Nulato Formations and the Ungalik Conglomerate exposed to the onshore to the east (Patton, 1973) and probably underlie a large part of Norton Sound (Scholl and Hopkins, 1969). The sedimentary package is bordered to the south by Quaternary basalt flows, to the east by Mesozoic granitic and andesitic rocks juxtaposed by the Chirosky Fault, and to the north by the Kaltag Fault which crosscuts and deforms the Cretaceous strata (Ramsey and other, 1986). Patton (1973) reports an Early Tertiary age for the Unalakleet coal, based on pollen, and Ramsey and others (1986) speculate this coal is part of a nearly continuous Late Cretaceous to Early Tertiary depositional sequence.

The Quaternary and Tertiary to Cretaceous sedimentary section crops out on the beach bluff south of Unalakleet but is complicated by the presence of large slump blocks (see Plate 9) resulting from partial thawing of exposed permafrost and subsequent slope failure. Elsewhere, these rocks are exposed in the banks of deeply incised streams. Ramsey and others characterize the coal-bearing portion of the exposed beach section as

> "a complex assemblage of unconsolidated silt, clay, coal, and ash lenses intercalated with indurated sandstones and shales. Lateral facies changes are frequent and abrupt; and few beds have a lateral extension of more than 50 ft. Low angle crossbeds (< 10°) are the most common sedimentary structures" (1986, p. 65).

Subsurface stratigraphy determined by drilling reveal a section dominated by silt and clay with discontinuous coal lenses unconformably overlain by 20 to 50 ft of Holocene and Quaternary unconsolidated sediments. The Quaternary sediments, deposited in alluvial fans shed from the local highlands, contain ice as accretionary wedges and interstitial void fillings up to 80% by volume in places (Ramsey and others, 1986). Coal lenses were intercepted by seven of the drill holes (Plate 9) with the thickest coal (2-ft-thick) in drill hole DH-U1-83 (Ramsey and others, 1986).

Coal quality

The quality of Unalakleet coal is variable with an average *as-received* heating value of 8206 Btu/lb, 23.61% moisture, 31.77% fixed carbon, 8.86% ash, and 0.15% total sulfur (appendix, p. 59). The thicker exposed lenses of coal are lignite in rank while many thinner coal horizons and streaks, not analyzed, have an apparent higher rank. Coal chips recovered from the 2-ft-thick coal lens in DH-U1-83 contain vitrain and plant fragments (Ramsey and others, 1986).

Coal resources

The largest lens of exposed coal occurs at the mouth of Coal Mine Creek, where a 6-ft-wide pod of clayey lignite pinches out laterally within 20 ft. This coal is probably the same bed mined in 1918 and now contains limited reserves. Drilling results indicate the coal-bearing strata south of Unalakleet dips 40° to 45°E (Ramsey and others, 1986) suggesting that coal exposed in the bluffs, if continuous, lies at considerable depth onshore. The depositional environment of the Tertiary section at Unalakleet is interpreted as a marginal marine, distributary system of a lower delta plain, an unlikely setting for extensive and continuous coal deposition (Ramsey and others, 1986).

13) ST. LAWRENCE ISLAND

History and Investigations

Coal on St. Lawrence Island was first utilized by the local Siberian Yupik Eskimos who burned it with driftwood in their campfires and communal houses. Early geologic investigations of St. Lawrence Island were primarily coastal surveys (Dawson, 1894; Emerson, 1904; Collier, 1906) or associated with archaeological excavations (Geist and Rainey, 1936). Little was known about the geology of the island's interior until later work by Patton and Csejtey (1971a, 1971b, 1980), Jones and Forbes (1976), and C.C. Hawley and Associates (1978).

In 1981 ADGGS and Dan Renshaw explored the western part of St. Lawrence Island for coal occurrences. An apparent promising site near Naskak on the western shore of Niyrakpak Lagoon was recommended for further exploration and trenching (Renshaw, 1981). A limited drilling program was conducted at the site in 1982 with disappointing results (Renshaw, 1982) and the remaining portions of the island were explored by helicopter and on foot for coal resources in 1983 (Renshaw, 1983). Coal localities reported in previous literature and by local inhabitants were visited and a few samples for quality analysis were taken.

Geology

St. Lawrence Island contains a thick section of Paleozoic and Mesozoic sedimentary rocks similar to coeval rocks exposed in Chukostk Peninsula, U.S.S.R., and in the Brooks Range of northern Alaska (Patton and Dutro, 1969) and a wide variety of Cretaceous to Tertiary plutonic and volcanic rocks (Patton and Csejtey, 1971b). The Kookooligit Mountains, south of the village of Savoonga, were formed by extensive Pleistocene basalt flows which overlie thin coal-bearing Tertiary sediments. Several cinder cones related to the Kookooligit volcanic extrusives still remain.

The coal-bearing sediments consist of poorly consolidated sandstone, grit, and conglomerate, carbonaceous mudstone, ashy tuff, volcanic breccia, and lenses of lignitic coal up to 18 in. thick. The low grade lignite coal, Oligocene in age (Patton and Csejtey, 1980), occurs along drainages and shores of lagoons on St. Lawrence Island (Plate 1). Several previously reported coal localities were shown to be vitrified bedded-volcanics with an appearance of coal while others are erosional coal float along drainages (Renshaw, 1983). Coal fragments were recovered from a water-well drill hole at Savoonga where it is overlain by the Kookooligit volcanics.

A minor occurrence (6 in.) of lignite is exposed on the southwest bank of Fossil River, 7 mi from its mouth (Plate 1). The seam walls consist of silty clays and are adjacent to volcanic rocks. The attitude of the coal seam is indiscernable due to frost heaving and subsequent slumping. Lignite coal and coalified wood fragments also occur along the east side of Koozata River (Plate 1) where volcanic rocks predominate. A thin seam of coal (4 in.) is exposed within approximately 30 ft of unconsolidated sediments.

The thickest coals are exposed on the west shore of Niyrakpak Lagoon and at the south end of Aghnaghak Lagoon (Plate 1). Four shallow trenches dug into the bluff at Niyrakpak Lagoon (trench locations shown on Plate 10) reveal coal lenses up to 18 in. thick within carbonaceous shale, clay and sand (Renshaw, 1981). In 1982 twelve auger holes were drilled into the tundra west of the trench sites to determine the lateral continuity of the coal. A cumulative total of 353.5 ft of drilling intercepted very little coal and mostly dark gray clay with gravel, carbonaceous clay, silt, with permafrost (between 3 ft and 12 ft) and discontinuous ice lenses to 30 ft depth (Plate 10) (Renshaw, 1982). The most abundant coal intercepts were encountered in hole DH10 which was drilled adjacent to 1982 trench no. 1.

Coal quality

The quality of St. Lawrence Island coal is highly variable with an average *as-received* heating value of 8267 Btu/lb, 28.13% moisture, 32.40% volatile matter, 34.31% fixed carbon, and 0.98% total sulfur (appendix, p. 59). Heat and pressure from coeval volcanic processes appears to have assisted in the coalification of available organic material (Renshaw, 1983).

Coal resources

Based on the results of drilling, Renshaw (1982) concludes that the coal exposed on the bluff and in trenches at Niyrakpak Lagoon has little lateral continuity and suggests that the high rate of bluff erosion will probably remove the remaining coal in a few years. The results of the 1981-83 St. Lawrence Island field investigations indicate that coal resources on the island are very limited. Many of the coal beds are associated with volcanic-derived sediments and apparently formed in small volcanic basins between eruptive periods (Renshaw, 1983).

CONCLUSIONS

The diverse quantity and quality of coal in northwestern Alaska (Fig.s 13 and 14) is directly related to disparate depositional settings and ages. The most abundant high quality coal resources are the Cretaceous coal found at Cape Beaufort and to the north. The likelihood that these resources will be mined by both surface and underground techniques is high. A mining plan developed by Arctic Slope Regional Corporation for the Deadfall Syncline proposes mining 300,000 tons of coal per year for local use and export and would employ more than 300 workers.

The second most abundant coal resource in the region exists in the Tertiary-age basins on Seward Peninsula where very thick coal beds of limited areal extent occur. A mining plan for Chicago Creek developed by C.C. Hawley and Associates would open pit mine 50,000 short tons of coal per year for 30 years out of demonstrated resources of 3,429,000 short tons to supply a power plant in Kotzebue. Other Tertiary coal deposits with limited potential under current market conditions include the Death Valley-Boulder Creek basin where a 175-ft-thick bed of subsurface coal and a 35 ft-thick-coal in outcrop at Grouse Creek is known. Undiscovered Tertiary coal on Seward Peninsula may be considerable.

The most difficult to extract yet highest quality coal in the region is the Mississippian-age coal at Cape Dyer on the Lisburne Peninsula. Coal here is up to semianthracite in rank but is structurally complicated due to local and regional tectonics. The high rank and near tide-water location may provide incentive for further exploration by industry and government.

Coal in northwestern Alaska, as throughout the state, is low in total sulfur and generally low in pyritic sulfur which is of great importance in light of new and future coal-burning regulations. The demand for low-sulfur coal is expected to rise in the United States and worldwide. The 125 northwestern Alaska coal Point IDs and 231 coal quality analyses entered into NCRDS (to date) provides an accurate database file of known low-sulfur coal resources in the region. It is our hope that the currently available AKSTRAT and USALYT files will be utilized by the public, Federal and state agencies, and industry seeking information on the coal resources of northwestern Alaska.

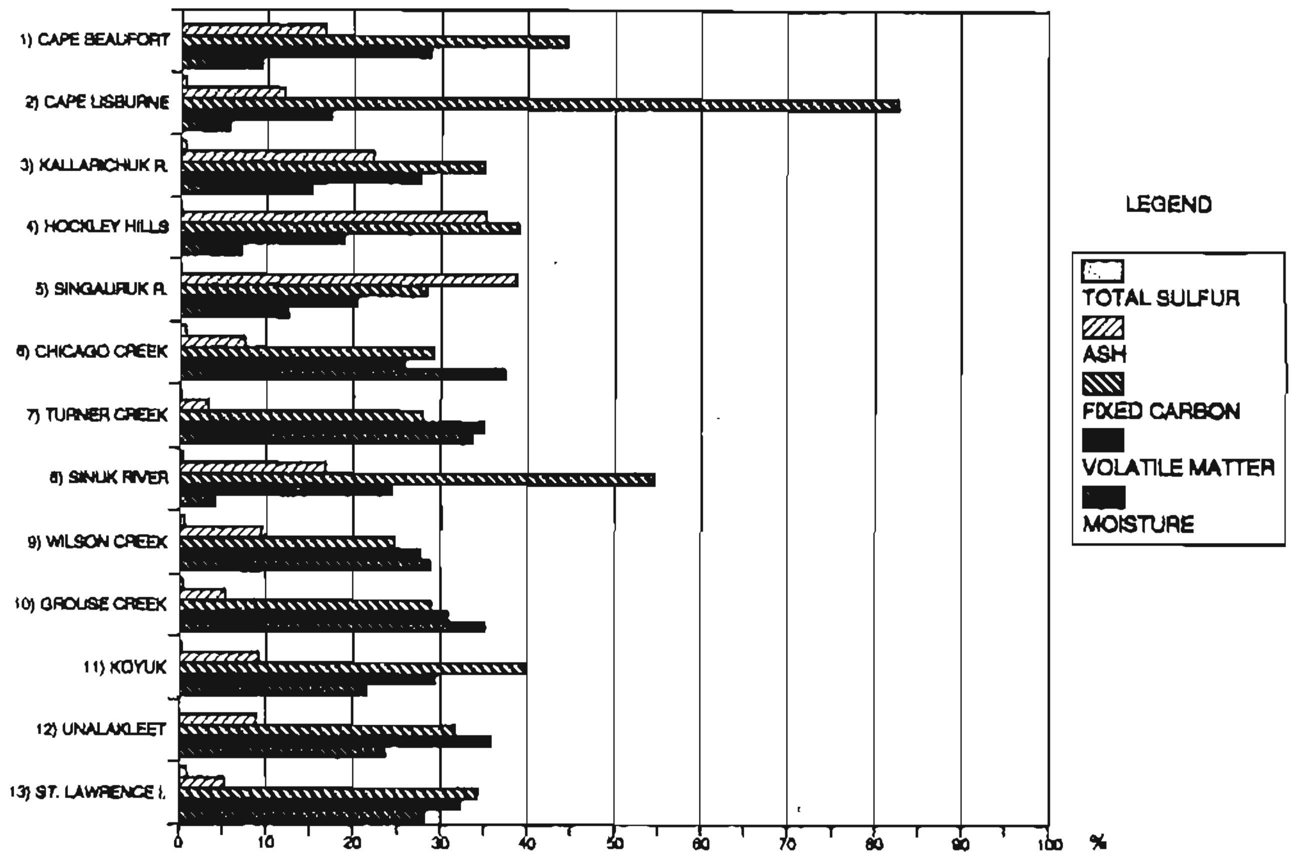

Figure 13. Bar graph of average *as-received* percentages of moisture, volatile matter, fixed-carbon, ash and total sulfur for thirteen northwestern Alaska areas. Average values from data entered in NCRDS *USALYT* files and given in appendix.

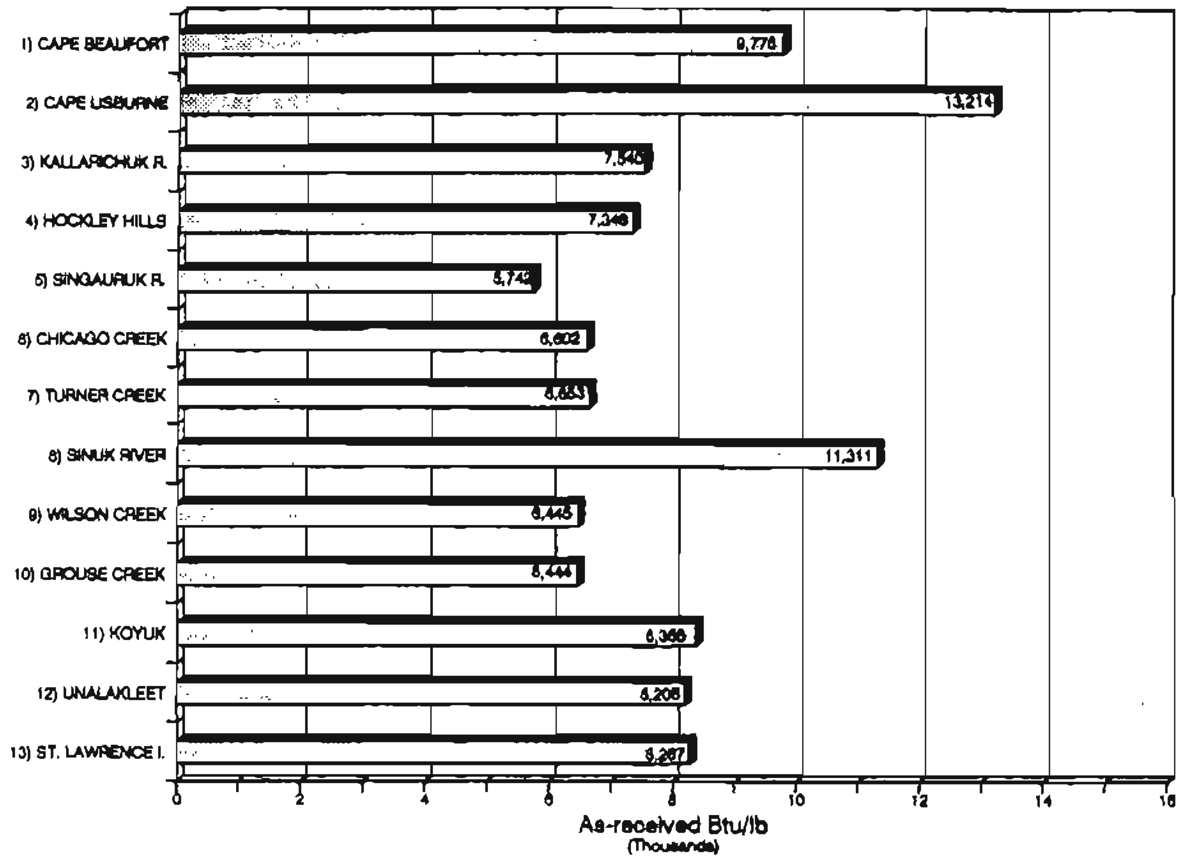

Figure 14. Bar graph of average Btu/lb heating values for thirteen northwestern Alaska areas. Average values from data entered in NCRDS *USALYT* files and given in appendix.

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APPENDIX

Listing of PointIds and coal quality data entered into NCRDS for thirteen northwestern Alaska coal localities

1) CAPE BEAUFORT/DEADFALL SYNCLINE [PT. LAY, DE LONG MOUNTAINS AND PT. HOPE QUADS]

PointId	Lat.	Long.	Unit #	Depth	Btu	Moisture	Vol. Matter	Fixed Carbon	Ash	H	C	N	O	Sulfur (pyritic)	Sulfur (total)
SS70-11W	685425 N	1642002 W	*	**	11570	3.9	36.4	45.7	14.0	5.2	65.6	1.9	12.8		0.5
SS70-17W	685412 N	1644150 W	*	**	9900	10.0	30.4	46.4	13.2	5.0	57.9	1.8	21.7		0.4
SS70-19W	685408 N	1644120 W	*	**	6010	6.0	18.5	27.2	48.3	3.2	34.9	1.1	12.3		0.2
SS70-27W	685355 N	1644525 W	*	**	9710	14.2	30.0	48.6	7.2	4.9	58.0	1.6	29.9		0.4
SS70-28W	685353 N	1644607 W	*	**	8400	12.9	32.5	41.0	13.6	4.7	51.4	1.5	28.4		0.4
SS70-29W	685353 N	1644639 W	*	**	8460	12.9	33.4	40.6	13.1	4.8	51.8	1.5	28.69		0.2
SS70-30W	685340 N	1644938 W	*	**	6480	12.6	24.9	31.4	31.1	4.0	39.9	0.9	23.7		0.4
			*	**	8970	12.9	34.0	42.1	11.0	4.9	54.8	1.3	27.6		0.4
			*	**	9040	13.2	32.7	44.2	9.9	4.9	54.6	1.5	28.8		0.3
			*	**	9770	12.3	34.1	47.8	5.8	5.1	58.9	1.5	28.3		0.4
			*	**	6060	12.1	25.9	30.4	31.6	3.9	37.9	1.2	25.2		0.2
SS70-30WA	685340 N	1644938 W	*	**	6480	12.6	24.9	31.4	31.1	4.0	39.9	0.9	23.7		0.4
			*	**	8970	12.9	34.0	42.1	11.0	4.9	54.8	1.3	27.6		0.4
			*	**	9040	13.2	32.7	44.2	9.9	4.9	54.6	1.5	28.8		0.3
			*	**	9770	12.3	34.1	47.8	5.8	5.1	58.6	1.5	28.8		0.3
			*	**	6060	12.1	25.9	30.4	31.6	3.9	37.9	1.2	25.2		0.2
SS70-31W	685344 N	1644736 W	*	**	9670	15.7	32.4	49.0	2.9	5.0	59.2	1.3	31.3		0.3
SS70-32W	685344 N	1644829 W	*	**	10400	12.6	28.8	53.2	5.4	4.9	62.3	1.2	25.8		0.4
			*	**	9510	15.0	31.7	58.0	6.3	5.2	48.0	1.1	29.2		0.2
			*	**	11690	8.0	30.4	56.3	5.3	5.1	68.5	1.3	19.6		0.2
			*	**	8200	17.3	31.6	40.3	10.8	4.9	50.8	1.1	32.1		0.3
SS70-33W	685339 N	1644907 W	*	**	11080	9.1	27.6	57.4	5.9	4.5	66.9	1.1	21.4		0.2
			*	**	12450	5.6	39.4	48.7	6.5	5.3	69.3	1.37	17.3		0.3
			*	**	12030	5.3	39.5	48.7	6.5	5.3	69.3	1.3	17.3		0.3
SS70-73W	685225 N	1650701 W	*	**	12030	4.4	37.4	48.8	9.4	5.1	68.8	1.6	14.9		0.2
SS70-74W	685211 N	1650815 W	*	**	9160	13.2	35.4	44.3	7.1	5.1	56.1	1.4	30.1		0.2
SS70-80W	685222 N	1650726 W	*	**	10400	9.1	34.3	48.8	7.8	4.9	61.9	1.3	23.9		0.2
SS70-82W	685203 N	1650947 W	*	**	9080	12.7	34.0	42.4	10.9	5.1	54.6	1.3	27.7		0.4
SS70-83W	685205 N	1650923 W	*	**	8190	11.1	32.6	36.6	19.7	4.7	49.5	1.1,	24.6		0.4
SS70-88W	685233 N	1650413 W	*	**	9740	11.7	32.7	47.4	8.2	4.9	58.6	1.2	26.7		0.4
73DSAH1	690639 N	1632313 W	2	4.5	8620	6.3	23.5	43.3	26.9	3.7	51.5	0.9	16.8		0.2
73DSAH2	690812 N	1632248 W	2	2.7	***	17.9	25.9	37.9	18.3						***
73DSAH3	690828 N	1632353 W	*	3	9000	14.1	27.9	45.7	12.3						0.2
73DSAH4	691107 N	1631117 W	*	3	10390	13.4	29.9	51.3	5.4	5.3	61.9	1.4	25.8		0.2
73DSAH5	691047 N	1631128 W	*	4	9380	12.7	25.9	48.4	13.0	4.5	57.0	1.1	24.3		0.1
73DSAH6	691056 N	1631332 W	*	4	9430	14.3	28.4	47.8	9.5	4.9	57.2	1.0	27.2		0.2
73DSAH8	691007 N	1630848 W	*	4.5	9370	13.7	28.5	47.6	10.2	4.8	56.7	1.0	27.1		0.2
73DSAH10	691025 N	1631028 W	*	5	10400	12.5	28.5	53.5	5.5	4.8	62.7	1.3	25.4		0.3
73DSAH23	690935 N	1630829 W	*	4.5	9300	13.7	29.8	46.2	10.3	4.9	56.5	1.1	19.7		0.2
			*	7	***	11.7	29.6	43.6	15.1						***
73DSAH24	691008 N	1630854 W	*	3	9070	16.0	28.3	45.6	10.1	5.0	54.7	1.0	29.0		0.2
73DSAH25	691008 N	1630854 W	*	4	8160	13.7	25.6	41.4	19.3	4.5	49.9	0.9	29.0		0.2
73DSAH27	691051 N	1631727 W	*	4	10100	15.6	29.2	51.1	4.1	5.3	60.5	1.3	28.6		0.2
83-1	691045 N	1632349 W	5	5	11256	2.29	29.67	49.09	18.94						0.24
83-2	691108 N	1632332 W	4	61	11966	5.41	26.51	56.75	11.33						0.40
			4	69	13206	4.78	32.31	57.69	5.22						0.28
			4	69	11450	4.79	30.26	48.41	16.54						0.27
83-3	691047 N	1631535 W	4	88	13001	3.95	32.40	56.97	6.68						0.25
			4	94	12543	3.45	32.59	53.20	10.77						0.3
83-4	691039 N	1631533 W	3	51	11470	4.67	28.73	52.01	14.60						0.21
			3	58	11133	3.83	30.84	47.13	18.19						0.28
83-5	691030 N	1631520 W	3	82	11967	4.21	30.27	53.71	11.81						0.27
			3	84	11228	4.62	30.35	47.84	15.02						0.24
83-6	691024 N	1631459 W	3	66	11667	4.38	31.00	49.60	15.57						0.26
83-8	690932 N	1630751 W	2	25	11358	5.51	29.61	49.32	15.57						0.26
			2	28	11165	11.47	30.03	47.12	11.39						0.20
83-8-C	690932 N	1630751 W	5	51	12593	5.30	33.08	53.15	8.47						0.22
			4	55	9509	2.16	26.21	41.16	30.47						0.27
83-9 .	690912 N	1630821 W	4	55	9509	2.16	26.21	41.16	30.47						0.27

Pointid	Lat.	Long.	Unit #	Depth	Btu	Mois-ture	Vol. Matter	Fixed Carbon	Ash	H	C	N	O	Sulfur (pyritic)	Sulfur (total)
83-10	690803 N	1630759 W	3	69	11513	3.43	30.89	50.17	15.51						0.24
			3	74	13266	3.25	34.82	56.25	5.68						0.20
			5	125	12484	2.86	33.45	52.32	11.37						0.27
83-11	690722 N	1631021 W	3	47	10438	3.46	27.93	45.33	23.28						0.29
			3	50	11448	3.42	31.76	48.97	15.85						0.21
			3	55	11989	3.45	33.23	49.60	13.73						0.20
			3	60	12722	3.57	34.29	52.99	9.15						0.20
			3	63	11777	3.53	32.50	48.77	15.20						0.22
83-12	690753 N	1632303 W	5	67	9454	3.66	24.57	45.78	25.99						0.15
83-16	690414 N	1633441 W	5	96	9401	7.22	28.14	37.62	29.02						0.26
			5	100	9831	6.02	32.03	36.71	25.25						0.24
			5	102	11163	6.72	32.16	45.14	15.98						0.22
83-17	690453 N	1633937 W	4	63	9327	23.25	25.03	35.16	16.56						0.35
			4	68	8466	21.50	26.33	34.65	17.52						0.40
83-19	690014 N	1633041 W	1	1	5976	28.46	23.21	27.90	20.43						0.21
83-20	690608 N	1631721 W	1	4	6276	23.68	21.12	27.81	27.39						0.32
83-21	690634 N	1631312 W	3	78	12507	5.02	35.12	50.81	9.05						0.22
			3	83	12780	6.05	35.37	51.12	7.46						0.19
83-22	690453 N	1633818 W	3	49	10093	5.82	29.28	41.94	22.95						0.35
83-201	693344 N	1623752 W	3	33	10923	6.53	29.03	46.71	17.73						0.50
			5	80	9544	6.36	25.96	41.32	26.36						0.33
			7	112	9097	5.40	28.11	36.16	30.33						0.21
83-203	691922 N	1624109 W	5	86	9448	11.75	27.65	48.19	12.41						0.31
			5	91	10077	9.96	29.09	48.99	11.96						0.18
			5	96	11549	8.12	31.34	54.55	5.99						0.28
			5	101	9980	8.32	28.00	46.03	17.65						0.45
83-206	691553 N	1625548 W	3	137	6495	7.35	19.31	26.78	46.56						0.35
			3	42	10850	5.57	29.28	46.05	19.10						0.32
			5	87	2530	17.82	13.05	8.51	60.62	—	—	—	—	—	0.21
			AVERAGE		9976	9.38	28.87	44.55	16.73	6.00	71.74	1.64	32.24		0.27

2) CAPE LISBURNE (PT. HOPE QUAD)

Pointid	Lat.	Long.	Unit #	Depth	Btu	Mois-ture	Vol. Matter	Fixed Carbon	Ash	H	C	N	O	Sulfur (pyritic)	Sulfur (total)
83CD-3	683825 N	1661249 W	*	**	13060	7.13	10.96	75.52	6.39	4.02	77.71	1.13	10.22		0.53
			*	**	14150	4.47	11.98	81.80	1.75						0.49
83CD-5	683828 N	1661250 W	*	**	13439	13.28	11.58	72.10	3.04						0.81
83CD-6	683829 N	1661249 W	*	**	13029	10.69	11.25	75.33	2.73						0.52
83CD-7	683820 N	1661250 W	*	**	11457	5.39	10.82	66.56	17.24						0.54
83CD-8	683815 N	1661258 W	*	**	12796	5.60	13.62	71.00	9.77						0.48
83CD-9	683801 N	1661301 W	*	**	14731	2.06	13.10	83.24	1.60						0.60
83CD-10	682328 N	1655725 W	*	**	11879	12.81	9.56	70.21	7.42						0.50
83CD-11	682423 N	1655912 W	*	**	***	0.36	5.99	1.92	91.73						0.06
82GE7C	682422 N	1655912 W	*	**	13208	6.17	43.44	47.28	3.11						0.60
H24240	683828 N	1661250 W	*	**	11800	3.0	12.8	68.2	16.0						0.90
H24241	683828 N	1661249 W	*	**	14010	3.0	14.1	80.0	2.9						0.60
H24242	683829 N	1661250 W	*	**	14280	2.0	15.0	79.0	4.0						0.50
H24243	683829 N	1661250 W	*	**	14140	2.0	15.40	79.40	3.2						0.80
H24244	683830 N	1661250 W	*	**	13150	2.1	12.50	75.7	9.70						0.60
H24245	683830 N	1661250 W	*	**	13760	2.9	13.5	80.1	3.5						0.80
H24246	683830 N	1661250 W	*	**	12860	2.3	15.9	71.6	10.2						0.50
NIAK CREEK	684031 N	1661251 W	*	**	13887	3.77	15.64	77.65	2.94						***
KILIKTUKGOT	683224 N	1661251 W	*	**		5.51	21.16	70.33	3.00						0.96
KAPALOAK	683022 N	1661251 W	*	**	___	1.71	15.62	79.86	2.8						***
			AVERAGE		13114	5.66	17.29	82.75	11.95						0.63

3) KALLARICHUK RIVER [BAIRD MOUNTAINS QUAD]

Pointid	Lat.	Long.	Unit #	Depth	Btu	Moisture	Vol. Matter	Fixed Carbon	Ash	H	C	N	O	Sulfur (pyritic)	Sulfur (total)
82GE1	671201 N	1594532 W	*	**	9292	13.20	32.15	41.68	12.97	5.34	52.68	0.82	27.13	0.41	1.06
82GE2	671301 N	1594530 W	*	**	5788	17.15	23.30	28.38	31.17						0.38
			AVERAGE		7540	15.18	27.73	35.03	22.21						0.72

4) HOCKLEY HILLS [SELAWIK QUAD]

Pointid	Lat.	Long.	Unit #	Depth	Btu	Moisture	Vol. Matter	Fixed Carbon	Ash	H	C	N	O	Sulfur (pyritic)	Sulfur (total)
82JC3	664656 N	1601959 W	*	**	9496	12.77	26.52	48.90	11.81	4.88	57.24	0.96	24.65	0.46	0.14
82JC1	665418 N	1602630 W	*	**	5196	1.46	11.11	28.76	58.67						0.25
			AVERAGE		7346	7.12	18.82	38.83	35.24						0.20

5) SINGAURUK RIVER [SELAWIK QUAD]

Pointid	Lat.	Long.	Unit #	Depth	Btu	Moisture	Vol. Matter	Fixed Carbon	Ash	H	C	N	O	Sulfur (pyritic)	Sulfur (total)
82OE3	664656 N	1601959 W	*	**	6948	15.23	22.18	34.97	27.62						0.35
82OE4	664656 N	1601959 W	*	**	4125	9.91	16.51	21.07	52.51	3.10	26.59	0.46	17.08	0.01	0.26
			*	**	5937	15.86	21.46	30.11	32.57						0.28
82JC2	664656 N	1601959 W	*	**	5959	9.13	21.27	27.39	42.21						0.24
			AVERAGE		5742	12.53	20.36	28.39	38.73						0.28

6) CHICAGO CREEK [BENDELEBEN QUAD]

Pointid	Lat.	Long.	Unit #	Depth	Btu	Moisture	Vol. Matter	Fixed Carbon	Ash	H	C	N	O	Sulfur (pyritic)	Sulfur (total)
82CCDH1	655421 N	1622549 W	4	112.6	6377	36.44	24.39	28.26	10.91	6.66	38.03	0.69	42.71	0.44	0.99
			4	123.0	6416	38.73	23.97	28.32	8.98	6.83	37.43	0.76	45.37	0.03	0.63
			4	132.0	6692	36.03	25.74	28.51	9.72	6.74	38.37	0.04	43.72	0.47	1.41
			4	141.0	6949	38.97	25.57	30.77	4.69	7.04	40.22	0.74	46.51	0.06	0.81
			4	150.0	6493	37.09	24.17	28.16	10.58	6.87	37.65	0.59	42.81	0.40	1.50
			4	160.0	5607	36.83	21.05	25.38	16.73	6.41	33.28	0.70	42.12	0.08	0.75
			4	180.0	7042	37.06	26.22	30.64	6.09	6.83	40.10	0.71	44.36	0.65	1.91
			4	190.0	6592	40.71	24.72	28.28	6.29	7.18	38.02	0.70	46.82	0.10	1.00
			4	202.5	6940	40.10	26.49	28.59	4.82	7.22	39.37	0.70	45.92	0.83	1.98
			4	212.5.	6446	43.69	24.93	26.65	4.73	7.40	36.76	0.63	48.47	0.93	2.02
82CCDH4	655418 N	1622547 W	2	40.0	7109	37.10	27.26	31.73	3.91						0.49
			2	47.5	6987	39.45	26.88	31.15	2.52						0.64
			2	51.5	6269	36.31	28.58	24.83	10.29						0.59
			2	57.5	6880	41.41	25.39	30.37	2.84						0.62
			2	62.0	7017	40.76	25.93	30.34	2.97						0.55
			2	68.0	7750	34.19	28.43	34.26	3.12						0.73
			2	73.5	7992	30.53	29.94	35.66	3.87						0.67
			2	80.0	8007	31.23	30.66	34.74	3.37						0.65
			2	87.0	7799	30.87	29.47	34.43	5.23						0.71
			2	94.5	7958	28.99	29.68	35.42	3.91						0.56
			2	101.5	8209	29.61	30.14	37.11	3.14						0.66
			2	112.0	7959	32.08	29.80	34.56	3.56						0.98
			2	118.0	8099	29.04	29.07	37.75	4.13						0.67
			2	130.0	8226	28.23	30.29	37.62	3.86						0.61
			2	138.0	7887	30.82	29.12	36.39	3.67						0.63

Polarid	Lat.	Long.	Unit #	Depth	Btu	Moisture	Vol. Matter	Fixed Carbon	Ash	H	C	N	O	Sulfur (pyritic)	Sulfur (total)
82CCDH8	655504 N	1622538 W	2	47.0	7411	35.32	27.74	32.52	4.42						1.15
			2	54.0	7049	38.07	26.73	30.46	4.75						1.34
			2	61.0	7412	34.85	27.67	32.71	4.77						1.07
			2	67.0	7037	35.30	27.07	29.94	7.69						1.07
			2	72.0	6175	36.59	24.16	26.53	12.71						0.74
			2	77.0	6471	34.28	25.55	27.70	12.47						0.85
82CCDH11	655441 N	1622554 W	2	31.5	6527	38.02	23.18	30.63	8.17						0.77
			2	31.5	6527	38.02	23.18	30.63	8.17						0.77
			2	40.0	6326	39.01	24.38	28.06	8.55						1.15
			2	42.5	7156	36.93	25.44	33.18	4.45						0.82
			2	48.0	6482	33.69	24.73	29.21	12.37						0.79
			2	53.0	6930	37.97	24.99	31.21	5.82						0.74
			2	58.0	6961	35.24	25.49	31.66	7.61						0.71
			2	63.0	6621	36.00	24.44	30.37	9.20						0.78
			2	68.0	6805	33.91	26.06	29.78	10.24						0.73
			2	73.0	6670	30.46	25.22	29.95	14.37						1.04
85CCDH1	654162 N	1622549 W	5	83.0	7499	35.67	29.46	30.59	4.28						0.56
85CCDH2	655413 N	1622548 W	4	221.0	7179	37.94	26.36	32.67	3.03						0.65
			4	222.0	5819	36.63	24.61	25.69	13.08						0.55
			4	232.0	6385	43.95	24.39	27.85	3.81						0.59
			4	236.0	7164	38.55	27.34	31.09	3.02						0.72
			4	263.0	6653	40.05	26.59	28.62	4.74						0.53
			4	264.0	7244	28.53	26.98	32.01	2.48						0.53
			4	269.0	6877	40.57	25.79	29.04	4.60						0.50
85CCDH3	655414 N	1622544 W	6	45.0	7011	37.17	26.37	31.40	5.06						0.54
85CCDH5	655411 N	1622541 W	4	84.0	5648	34.88	29.64	18.72	16.76						0.42
			4	86.0	6712	41.63	25.69	29.52	3.16						0.53
85CCDH6	655411 N	1622540 W	5	83.0	5586	44.24	22.59	24.59	8.58						0.49
85CCDH6	655411 N	1622540 W	3	68.0	7138	36.66	28.16	30.50	4.68						0.68
			3	95.0	5245	37.94	26.01	18.99	17.06						0.68
			3	82.0	6872	40.63	26.08	29.90	3.39						0.64
			3	87.0	6269	39.35	25.39	26.73	8.53						0.72
			3	93.0	6474	40.05	25.81	27.15	6.99						0.95
			3	95.0	7022	37.52	27.57	30.15	4.76						1.11
			3	97.0	4863	32.96	24.48	20.45	22.11						5.28
85CCDH17	655418 N	1622542 W	*	**	6372	43.05	23.95	27.86	5.13						0.64
85CCDH17	655418 N	1622542 W	6	38.0	6944	38.54	27.06	30.67	3.73						0.48
			6	48.0	7066	38.50	27.46	31.21	2.84						0.32
			10	130.0	6812	40.41	25.16	30.71	3.71						0.44
85CCDH21	655425 N	1622550 W	2	25.0	6905	39.30	24.70	32.11	3.88						0.52
			4	70.0	6659	42.19	24.85	29.26	3.70						0.85
			4	75.0	5175	40.72	20.13	23.19	15.96						0.70
			4	90.0	6414	41.86	23.50	28.00	6.64						1.23
85CCDH23	655430 N	1622553 W	3	60.0	6914	40.17	26.55	29.56	3.73						0.54
			3	65.0	7134	37.97	26.30	31.63	4.10						0.58
85CCDH23	655430 N	1622553 W	3	68.0	5460	24.70	26.07	21.02	28.21						1.04
85CCDH30	655436 N	1622559 W	4	47.0	4166	22.90	17.70	15.76	43.63						0.34
			4	47.0	5648	34.88	29.64	18.72	16.76						0.42
			4	53.0	6712	41.63	25.69	29.52	3.16						0.53
			4	100.0	6601	39.86	24.61	29.15	6.38						0.66
			4	108.0	6682	41.07	24.54	29.93	4.44						0.60
			4	130.0	6617	40.19	24.54	29.86	4.69						0.49
85CCDH34	655442 N	1622554 W	2	23.0	6577	39.62	26.13	28.88	5.37						0.65
			2	32.0	6741	42.48	25.60	29.14	2.78						0.64
			2	80.0	6135	43.25	22.88	27.16	6.70						0.99
			2	80.0	4902	46.26	22.88	27.16	6.70						0.99
			2	95.0	4902	46.65	20.02	21.94	15.35						1.78
			2	102.0	5414	40.52	21.49	22.46	15.53						1.25
85CCDH34	655442 N	1622554 W	2	113.0	6741	42.48	25.60	29.14	2.78						0.64
			2	123.0	6135	43.26	22.88	27.16	6.70						0.99
			AVERAGE		6602	37.36	25.81	29.22	7.58	6.92	37.92	0.63	44.88	0.40	0.85

7) TURNER CREEK [BENDELEBEN QUAD]

Pointid	Lat.	Long.	Unit #	Depth	Btu	Moisture	Vol. Matter	Fixed Carbon	Ash	H	C	N	O	Sulfur (pyritic)	Sulfur (total)
82GE8	653031 N	1641432 W	*	**	6653	33.56	34.98	28.00	3.46						0.16

8) SINUK RIVER [NOME QUAD]

Pointid	Lat.	Long.	Unit #	Depth	Btu	Moisture	Vol. Matter	Fixed Carbon	Ash	H	C	N	O	Sulfur (pyritic)	Sulfur (total)
82JC7	644424 N	1655542 W	*	**	11311	4.07	24.51	54.57	16.85						0.53

9) WILSON CREEK [CANDLE QUAD]

Pointid	Lat.	Long.	Unit #	Depth	Btu	Moisture	Vol. Matter	Fixed Carbon	Ash	H	C	N	O	Sulfur (pyritic)	Sulfur (total)
82OE7A	652115 N	1612601 W	*	**	6445	28.82	27.77	24.71	9.62						0.74

10) GROUSE CREEK [BENDELEBEN QUAD]

Pointid	Lat.	Long.	Unit #	Depth	Btu	Moisture	Vol. Matter	Fixed Carbon	Ash	H	C	N	O	Sulfur (pyritic)	Sulfur (total)
82OE6A	650255 N	1621647 W	*	**	7577	34.29	30.01	33.37	2.33	6.83	45.04	.34	44.52	0.94	0.41
82OE6B	650255 N	1621647 W	*	**	5310	35.60	31.54	24.55	8.31						0.78
			AVERAGE		6444	34.95	30.78	28.96	5.32						0.60

11) KOYUK [KOYUK QUAD]

Pointid	Lat.	Long.	Unit #	Depth	Btu	Moisture	Vol. Matter	Fixed Carbon	Ash	H	C	N	O	Sulfur (pyritic)	Sulfur (total)
85KOYTH18	655252 N	1610625	4	12	8561	21.35	29.41	40.98	8.26						0.31
82KOY1	655252 N	1610625 W	2	10	8459	22.25	29.25	40.24	8.27						0.30
82KDY2	655252 N	1610625 W	2	11	8461	21.43	29.55	41.43	7.58						0.28
82KOY3	655252 N	1610625 W	2	12	8567	20.65	29.22	41.91	9.22						0.28
82KOY4	655252 N	1610625 W	2	12	7836	23.11	29.25	36.85	10.79						0.47
82KOY5	655252 N	1610625 W	2	3	8367	20.73	29.19	38.10	11.99						0.42
82KOY6	655252 N	1610625 W	2	16	8102	21.56	29.95	38.09	10.40						0.44
82KOY7	655252 N	1610625 W	2	11	8393	21.65	28.37	40.58	9.40						0.43
82KOY8	655252 N	1610625 W	2	11.5	8502	21.96	29.66	40.39	7.99	50.05	5.75	0.68	35.20	0.03	0.32
82KDY9	655252 N	1610625 W	2	12	8580	21.62	29.80	40.49	8.10	50.03	5.64	0.70	35.23	0.03	0.31
82KOY10	655252 N	1610625 W	4	14	8647	21.18	29.97	40.94	7.91	50.79	5.62	0.66	34.72	0.03	0.31
82KOY11	655252 N	1610625 W	4	12	8561	21.35	29.41	40.98	8.26						0.31
82KOY12	655252 N	1610625 W	4	19	8017	22.39	28.93	37.95	10.73						0.40
82KOY13	655252 N	1610625 W	2	22	7775	23.47	29.27	37.77	9.49						0.31
82KOY14	655252 N	1610625 W	*	**	8497	21.43	28.93	40.70	8.94	50.31	5.59	0.67	34.11	0.02	0.39
82KOY15	655252 N	1610625 W	2	1	8885	21.28	32.23	42.10	5.39						0.45
82OE7B	652115 N	1612601 W	*	**	7995	21.27	27.77	37.88	13.08	—	—	—	—	—	0.63
			AVERAGE		8365	21.71	29.42	39.78	9.22	50.30	5.65	0.68	34.82	0.03	0.34

12) UNALAKLEET [UNALAKLEET QUAD]

Pointid	Lat.	Long.	Unit #	Depth	Btu	Mois-ture	Vol. Matter	Fixed Carbon	Ash	H	C	N	O	Sulfur (pyritic)	Sulfur (total)
82GE10	634601 N	1604544 W	*	**	7648	24.16	32.39	31.86	11.59						0.26
82JC8	634536 N	1604620 W	*	**	9190	21.39	42.56	30.90	5.15	6.85	51.92	0.65	34.80	0.55	0.02
UA-151	634614 N	1604535 W	*	**	7779	25.28	32.51	32.55	9.85	6.30	45.28	1.13	37.11	0.33	0.02
				AVERAGE	8206	23.61	35.82	31.77	8.86	6.58	48.60	0.89	35.96	0.44	0.15

13) ST. LAWRENCE ISLAND [ST. LAWRENCE ISLAND QUAD]

Pointid	Lat.	Long.	Unit #	Depth	Btu	Mois-ture	Vol. Matter	Fixed Carbon	Ash	H	C	N	O	Sulfur (pyritic)	Sulfur (total)
82AGH-1	633820 N	1714212 W	1	**	10418	6.10	50.91	39.66	3.33						1.22
82JC-101	633105 N	1712815 W	1	6	10445	35.18	26.20	33.18	5.43						0.68
82JC-108	633105 N	1712815 W	3	**	6843	37.63	24.56	32.37	5.45						0.58
83KR-1	632742 N	1703916 W	*	**	8573	19.71	36.97	38.53	4.79						0.49
83KR-2	632742 N	1703916 W	6	**	4490	54.03	22.71	20.07	3.19						2.32
83FR-1	632324 N	1700358 W	1	**	8834	16.14	33.06	42.07	6.73						0.57
				AVERAGE	8267	28.13	32.40	34.31	5.15						0.98

All values *as-received*
Btu is Btu/lb *moist mineral-matter free*
Volatile Matter and Fixed Carbon *dry mineral-matter free*
* No unit number assigned
** No depth given or denotes surface sample
*** No value given
# An average of Niak, Killitrukgot, and Kapalook Creeks