

Public-data File 86-58

THE CHICAGO CREEK

AND

NORTON SOUND AREA

COAL EXPLORATION PROGRAMS

By

STEVEN'S EXPLORATION MANAGEMENT CORP.

K.H. Manning

D.L. Stevens

Alaska Division of
Geological and Geophysical Surveys

January 1986

THIS REPORT HAS NOT BEEN REVIEWED FOR
TECHNICAL CONTENT (EXCEPT AS NOTED IN
TEXT) OR FOR CONFORMITY TO THE
EDITORIAL STANDARDS OF DGGS.

794 University Avenue, Basement
Fairbanks, Alaska 99709

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STEVENS EXPLORATION MANAGEMENT CORP.

K. H. Manning
D. L. Stevens, Ph.D.

A Subcontract to Denali Drilling Inc.
for the State of Alaska,
Department of Natural Resources

31 January, 1983

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SUMMARY

Denali Drilling Inc., under contract to the State of Alaska, conducted a drilling program and geologic investigation of the Chicago Creek coal deposit which is located about 70 miles south of Kotzebue. A total of fourteen drill holes were completed. In four holes, the coal-bearing interval was cored. The recovered coal samples were sent to the Mineral Industry Research Laboratory for analysis. Natural gamma and density logs were run on eight of the drill holes and lithologic logs were made on every hole.

The coal occurrence at Chicago Creek has a strike which varies from due North to N 6° W and has a dip of about 70° in the upper portion of each hole and about 50° in the lower portion of each hole. The coal has a maximum true thickness of about 78 feet.

On an As Received Basis, the coal averaged 35.58% Moisture, 26.28% Volatile Matter, 30.86% Fixed Carbon, 7.28% Ash, and had a Heating Value of 6987 Btu/lb with 0.97% Total Sulfur. The Chicago Creek coal is classified as lignite in rank.

The steep dip of the coal seam combined with the limited depth to which drilling was contracted precluded the determination of sufficient reserves on which to develop a mining plan.

Additional exploration drilling will be necessary to properly evaluate the feasibility of developing the Chicago Creek coal to provide power for the Kotzebue area.

Upon completion of the drilling program at Chicago Creek, the contract with Denali Drilling Inc. was amended to provide for a reconnaissance examination of coal occurrences in the Norton Sound area. Reported coal occurrences south of Unalakleet, east of Koyuk, and on the east side of Death Valley, and near Elim were examined. Twenty two shallow holes were drilled at the Koyuk coal occurrence. Samples were collected from the Unalakleet and Omilak Creek areas. A total of eighteen samples were submitted to the Mineral Industry Research Laboratory for analysis. These data indicate that the coal occurrences near Koyuk and south of Unalakleet warrant further exploration.

Recommendations are made for further exploration of the Chicago Creek, Koyuk, and Unalakleet area coal occurrences.

RECOMMENDATIONS

The Chicago Creek coal exploration work completed to date strongly suggests that further exploration will delineate the reserves necessary to support a coal-fired power plant for the Kotzebue area. The following recommendations are made to complete the required exploration work.

(1) A drill rig capable of drilling suitable diameter holes to a depth of 1500 feet should be contracted for the work. Although conclusive evidence was not obtained, it appears from the drilling completed in 1982 that the dip of the coal flattens with depth and that there is a reasonable chance that 1500 foot holes will be sufficient to establish the reserves present.

(2) A second row of drill holes parallel to those drilled in 1982 and offset about 250 feet west should be drilled. This second row of holes should be drilled with the holes positioned 250 feet east of drill holes DH-4, DH-6, DH-11, DH-12, DH-7, DH-8, and DH-9. Upon successful completion of these holes and the favorable determination of coal continuity and thickness, a third row of holes should be drilled parallel to the second, offset another 250 feet, with the holes corresponding in position to the previous holes to facilitate construction of cross-sections to aid in understanding the structure of the coal deposit. Once the attitude of the coal seam is understood, subsequent drilling could be done on a wider grid spacing. Drilling should continue

until the limits of the coal are found and the total reserves determined. A lithologic log should be made of each hole and gamma ray and density logs run on each hole. Every fourth hole should have the coal interval cored and sampled so that the physical, chemical, and engineering properties of the coal can be determined.

The Koyuk coal occurrence should be explored further as follows:

- (1) A geologic map of the area should be compiled;
- (2) A drilling program consisting of a maximum of 15 holes should be conducted. Lithologic, gamma ray, and density logs should be made and core of the coal interval sampled for analysis. The determination of the limits of the thickest portion of the coal occurrence would be the objective of this program.

The Unalakleet area coal occurrences need further exploration work. The recommended tasks are as follows:

- (1) Basic geologic mapping needs to be done in an effort to determine the distribution, size, and location of the areas with the best potential for substantial coal occurrences.
- (2) If the geologic mapping can identify one or more coal occurrences which warrant a drill program, a drill rig should be mobilized to the site and a drilling program initiated.

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INTRODUCTION

PURPOSE

The purpose of this report is to present the results of the work performed under contract to the Department of Natural Resources, Division of Geological and Geophysical Surveys.

The purpose of the program was to explore the Chicago Creek coal deposit to determine if sufficient mineable reserves are present to warrant development. The development of a coal-fired power plant is needed to lower the costs of power in the Kotzebue area.

CONTRACTORS

Denali Drilling Inc. submitted the low responsible bid and was selected as the contractor for the project. Stevens Exploration Management Corp. was subcontracted by Denali Drilling Inc. to provide the geologic expertise required and to prepare this report. Geo-Recon International, Limited was subcontracted by Denali Drilling Inc. to provide the gamma ray and density logs of each drill hole.

AUTHORIZATION

Contractual Document Number CA-12072 was authorized by the State of Alaska and awarded to Denali Drilling Inc.

SCOPE

The scope of the Chicago Creek project required the contractor to do geological exploration, survey in and drill approximately ten holes to a depth of about 300 feet, provide gamma ray, density and lithologic logs of each hole, complete a geologic map with cross-sections showing elevations and the location of each drill hole, and to sample coal beds encountered by drilling. The contractor was to provide a coal reserve estimate, a mining plan, and a narrative report of the project.

Prior to the completion of the Chicago Creek project, personnel with the Division of Geological and Geophysical Surveys decided to expand the scope of the contract to include reconnaissance surveys of reported coal occurrences in the Norton Sound area. Specifically, occurrences near Grouse Creek, Elim, Koyuk, and Unalakleet were selected for examination.

ACKNOWLEDGEMENTS

Gilbert R. Eakins, Chief Mining Geologist, and Jim Clough, Geologist, of the State of Alaska, Department of Natural Resources, Division of Geological and Geophysical Surveys, and Mike Menge and Gary Martin of the U. S. Minerals Management Service visited the project at various times and provided numerous suggestions and comments that were beneficial to the project.

Also very instrumental in the successful completion of the project were Rhinehart Berg, owner of the airstrip at Candle and Virgil Vial, owner of the placer camp near the project site. Without the use of these two facilities, the project would have been much more difficult.

The comfort of the Unalakeet Lodge was greatly appreciated during the Norton Sound portion of the project.

PART I. CHICAGO CREEK PROJECT

LOCATION

The location of the Chicago Creek project is shown on Figure 1. The old Chicago Creek Mine is located in Section 22, Township 6 North, Range 18 West, Kateel River Meridian. This location is about 70 miles south of Kotzebue, and 14 miles west of Candle. Chicago Creek is a tributary to the Kugruk River.

The surface of the land has been withdrawn from all forms of appropriation by the Alaska Native Claims Settlement Act of 1971 for selection by the village of Deering. If the land is conveyed to Deering, the regional corporation, NANA, will own the sub-surface mineral resources.

ACCESS

Equipment, supplies, groceries and fuels for the project were flown to Candle in a Hercules aircraft. Personnel flew to Kotzebue via commercial aircraft and on to Candle or the airstrip

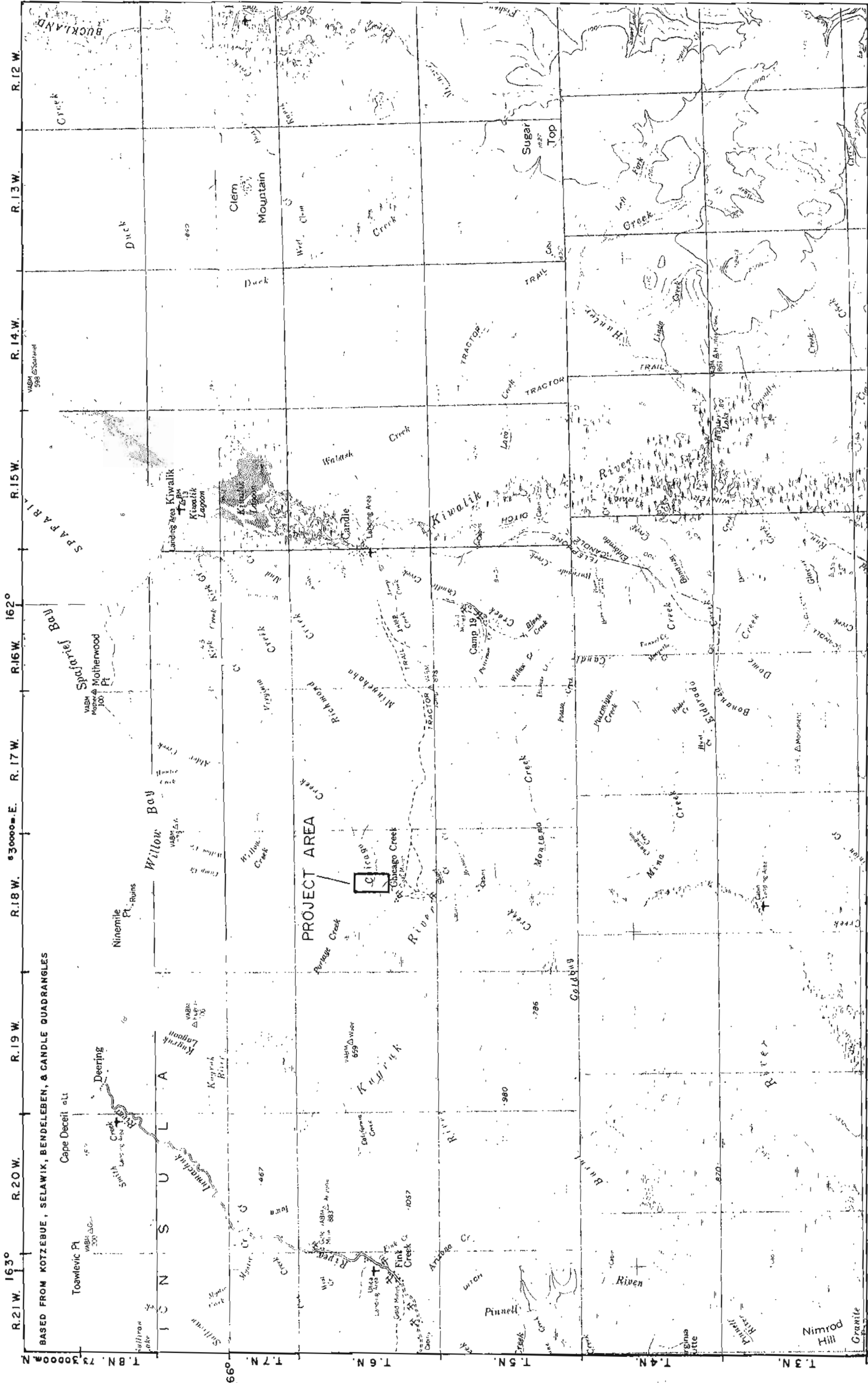


FIGURE 1 : LOCATION OF CHICAGO CREEK PROJECT

at Vial's Camp by charter aircraft based in Kotzebue. The drill rig was mounted on a Nodwell tracked vehicle which transported the rig and ancillary equipment and supplies to the project site. Project area personnel transportation was by a smaller tracked vehicle.

GEOGRAPHY AND ENVIRONMENT

The topographic relief in the immediate vicinity of the Chicago Creek area is only about 400 feet with the hills having gentle slopes and a general rounded appearance. To the east, the Kiwalik River occupies a linear north-south trough. Chicago Creek is a tributary of the Kugruk River and south of the Chicago Creek-Kugruk River confluence, the Kugruk also occupies a north-south trending topographic feature. The highest hills in the area are in the block between the north-south portions of these two rivers.

Tundra covers most of this region with a few scattered spruce on protected south-facing slopes. Underbrush consisting of dwarf birch and willow occurs along the streams and in protected areas.

Permafrost underlies all of this region and is responsible for the abundant standing water during the summer months. The climate is subarctic with an annual precipitation of 8.6 inches which includes 36 inches of snow. Summer temperatures range from

36° Fahrenheit to 63° F.; winter temperatures range from -20 to 2° F. Annual extremes are -60° in the winter to 85 ° in the summer.

The inhabitants of the region fall into two general categories: gold miners and natives. The natives generally live subsistence lifestyles aided by temporary employment when available. Most of the gold miners live in the area only during the mining season.

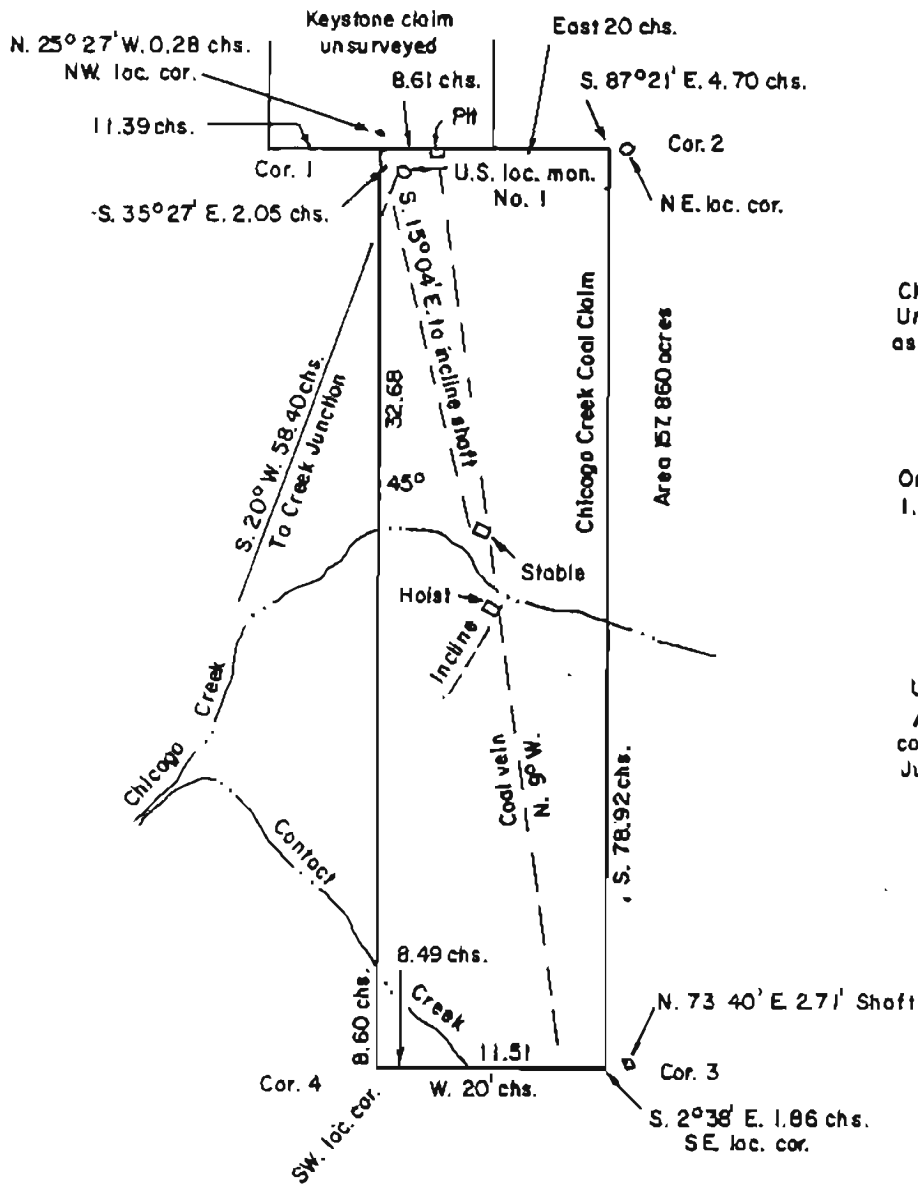
HISTORY AND PAST PRODUCTION

The Chicago Creek coal claim was located in 1905 and surveyed for patent April 16-18, 1907 (see Figure 2 Plat of U. S. Survey 194, Chicago Creek Mine) but the application for patent was rejected.

Henshaw (1909, p. 362-363) described the Chicago Creek Mine as follows:

The coal seam strikes about N. 8° W. and has a westerly dip of 53°. The strata in which the coal is included are soft and crumble easily. As nearly as could be determined from the exposures in the mine, the coal bed is 88 feet thick, with no partings except a few thin layers of bone and sandy shale. Drillings made during August, 1908, revealed the presence of the coal bed one-half mile N. 12° W., at depth of 69 feet below the surface. An inclined shaft that

From USBM RI 4150



PLAT
of
U. S. survey No. 194
Chicago Creek Coal Claim
Under act of June 6 1900
as amended by act approved
April 28, 1904
of
T. S. Solomons
Situated
On Chicago Creek, about
1.25 miles eastward from
the Kugruk River
District of Alaska
Variation 24° E
area 157,860 acres
As surveyed by
Arthur G Blake
U.S Deputy Surveyor
April 16-17-18, 1907
copied at U.S. land office
Juneau Alaska 11-27-45
66 feet to 1 chain

Figure 2. Plat of U. S. Survey 194, Chicago Creek mine.

follows the coal bed exposed on the left bank of Chicago Creek is 330 feet long and slopes downward at an angle of 18° to 36°. The shaft reaches a depth of 144 feet below its mouth and the bottom is more than 200 feet below the surface of the ground perpendicularly above it. The coal is solidly frozen to this depth. The incline lies 20 to 30 feet from the hanging wall down to a point near the lowest level where the irregularity of the dip of the coal bed brings them nearly together.

The mine has been worked on four levels at approximately 33, 80, 100, and 144 feet below the shaft house. On the upper level a crosscut 55 feet long was run in 1903, but did not reach the foot wall. On the lowest level a crosscut 104 feet long exposes the whole width of coal. The bed here is at least 85 feet thick, but appears to be somewhat thinner than at other points. On the upper three levels the coal has been taken from the portion of the seam lying within 20 feet of the hanging wall, which yields the solidest and most desirable fuel. Most of the coal mined in the last two years has been stoped from the area between the shaft and crosscut, and discharged by chutes into cars in the crosscut. The coal at the lowest level appears to be more uniformly good than it is higher up, where only the part of the bed nearest to the hanging wall was worked.

Total estimated coal production is estimated to have been

about 110,000 tons, most of which was used by the gold miners in the area.

REGIONAL GEOLOGY

The Seward Peninsula presents as diverse a geologic picture as any area of comparable size in North America. The geologic units range in age from Precambrian through Recent. Igneous rocks range from basaltic dikes and flows through tin granites. The structural history is very complex and only recently have geologists begun to untangle the complicated sequence of events which can only be understood on the basis of global plate tectonics.

The northeast quadrant of the Seward Peninsula, which includes the Chicago Creek area, has been mapped only at small scales but still has displayed a substantial complexity. North-south faults bound horst and graben structures. The horsts, like the terrain between the Kiwalik River and the north-trending portion of the Kugruk River, are composed of probable PreCambrian York Slate or its equivalent, which is the apparent source for the placer deposits in the area. The grabens contain the coal-bearing formations and other younger clastic and carbonate units.

PROJECT AREA GEOLOGY

Stratigraphy

The coal is overlain by silt with varying amounts of ice which ranges from 10 to 40 percent. There are occasional ice lenses up to three feet thick. The silt unit is generally dark brown with less than 10 percent sand and clay.

The coal is underlain by a clay unit varying from 2 to 10 feet thick. This clay unit parallels the lower contact of the coal and consists of light gray to white clay with traces of coal fragments in the upper foot of the bed. This clay unit is in unconformable contact with the older metasediments underlying it.

Structure

The coal-bearing unit dips steeply to the west. This attitude probably signifies proximity to the eastern fault on the margin of the graben. There is some indication in the drill core that the dip of the coal bed decreases with depth down the hole suggesting drag-folding near a fault.

Description of the Coal Seam

The coal seam is thickest on the south side of Chicago Creek with a true thickness of 78 feet. The coal seam abruptly ends at approximately 500 feet south of the old mine adit. On the north side of Chicago Creek the coal seam thins progressively. The northern-most drill hole, DH 9-82, intercepted only two feet of

coal at a distance of 4,192 feet from the adit. Near the adit, the coal has a strike of about North 6° West, with the strike changing progressively to the north to nearly due North. Near the adit, the dip of the coal seam is 68° to 72° in the upper half of the unit and 45 to 55° in the lower half. The dip becomes less steep to the north of the adit.

The coal is highly fractured with several prominent cleat and fracture patterns parallel to and intersecting the bedding planes. Zones of fractured coal contain silt and clay stringers along the fractures. The coal is frozen throughout with occasional ice crystals and stratified ice up to 1/4th inch in thickness. Cleats and fractures have traces of sulfide coatings with occasional pyrite crystals up to 1/4 inch on a side.

GEOPHYSICAL INVESTIGATIONS

GEO-RECON INTERNATIONAL, LTD. was contracted by Denali Drilling, Inc. to provide the geophysical work required by the contract. Natural gamma and gamma-gamma density logs were run on eight drill holes out of the 14 holes drilled. In addition to the required geophysical services, the geophysical contractor ran electromagnetic methods of resistivity mapping in an attempt to locate the subsurface trace of the coal outcrop since the published strike of the coal seam was not correct and some indicator was needed to accurately position the drill holes.

The results of these investigations are discussed in the report submitted by GEO-RECON INTERNATIONAL, LTD. which is included in this report as APPENDIX B REPORT OF GEOPHYSICAL STUDIES.

DRILLING METHODS

A Longyear Model 38 drill rig was mounted on a Nodwell FN-60 tracked carrier. A tricone bit was used to initiate each hole and to advance the hole to the coal seam. Once coal was encountered, an impregnated diamond step bit was used with a Christian-son split sleeve core barrel for core recovery. Since the ground temperature was well below freezing, Denali Drilling Inc. used proprietary fluids to maintain circulation and to prevent freezing the drill rods in the hole. The best core recovery was obtained with a five foot core barrel. Both HX and NX diameter cores were obtained.

The drill cuttings and recovered core were logged (See Appendix A Chicago Creek Drill Logs) and placed in plastic sleeves in wooden core boxes initially, but during the latter stage of the project, the plastic sleeves were not utilized.

A baseline was surveyed in oriented along the strike of the coal seam as reported in the old literature on the occurrence. Exact hole locations were then surveyed in from this baseline. The survey data for each hole is presented in Table 1.

TABLE 1 CHICAGO CREEK SURVEYING DATA

| DRILL HOLE NUMBER | BASE LINE DISTANCE (FEET) | BASE LINE OFFSET (FEET) | ELEVATION (FEET) | TOTAL DEPTH (FEET) |
|-------------------|---------------------------|-------------------------|------------------|--------------------|
| DH-1-82 | 1+53 S | 21 W BL I | 186 | 232.5 |
| DH-2-82 | 11+98 S | 00 BL I | 249 | 105.0 |
| DH-3-82 | 6+69 S | 00 BL I | 243 | 72.0 |
| DH-4-82 | 3+64 S | 22 W BL I | 212 | 230.0 |
| DH-5-82 | 7+13 S | 60 W BL II | 245 | 65.0 |
| DH-6-82 | 5+08 N | 00 BL II | 153 | 200.0 |
| DH-7-82 | 26+41 N | 77 E BL II | 232 | 130.0 |
| DH-8-82 | 31+44 N | 136 E BL II | 270 | 92.0 |
| DH-9-82 | 41+92 N | 186 E BL II | 326 | 70.0 |
| DH-10-82 | 15+87 N | 75 W BL II | 178 | 115.0 |
| DH-11-82 | 12+37 N | 00 BL II | 168 | 98.0 |
| DH-12-82 | 19+37 N | 00 BL II | 192 | 123.0 |
| DH-13-82 | 19+07 N | 30 E BL II | 189 | 132.0 |
| DH-14-82 | 19+37 N | 100 E BL II | 197 | 30.0 |

560

A permanent monument was placed at the site of the adit. Distances north and south were then measured from this monument along the baseline.

COAL ANALYSIS METHODS AND RESULTS

All coal samples obtained by core drilling were forwarded to the Mineral Industry Research Laboratory at the University of Alaska in Fairbanks, Alaska. These samples were analyzed by standard ASTM methods under the supervision of Dr. P. Dharma Rao, Professor of Coal Technology.

Two classes of coal analyses were run: (1) Ultimate analysis, and (2) Proximate analysis. An Ultimate analysis expresses the composition of coal in weight percentages of carbon, hydrogen, nitrogen, sulfur, oxygen, and ash. A Proximate analysis reports coal compounds in four groups: (1) moisture, (2) volatile matter consisting of gases and vapors driven off during pyrolysis, (3) mineral impurities as ash, and (4) fixed carbon, the remaining nonvolatile fraction of the pyrolyzed coal. The Proximate analysis is usually supplemented by determination of the sulfur content and an estimation of heating value expressed as Btu per pound.

The coal-bearing interval in Drill Holes 1, 4, 8, and 11 were shipped to the Laboratory for analysis. Both Proximate and Ultimate analyses were run on the core from Drill Hole 1; only

Proximate analyses were run on Drill Holes 4, 8, and 11. The results of these analyses are presented in Tables 2, 3, 4, and 5.

The intercept-weighted mean of the values reported on the Proximate analyses were calculated for each drill hole and are presented in Table 6. The weighted mean for all Proximate analysis values for all the drill holes was calculated and is presented in Table 6 also.

The analytical results can also be used to determine the rank of the coal. Figure 3 is a chart showing the fields of the various coal ranks and the formulas used in calculating the position on the chart. The average rank of the Chicago Creek coal is plotted on this chart.

COAL RESOURCES

Measured. Measured coal resources, the most precise category, are based on outcrop measurements, drill hole intersections, and reasonable projections between outcrops and drill holes. No coal outcrops are present because of the overburden and tundra cover so that a precise determination of the stratigraphic thickness is not possible. Therefore there is some possibility of error in determining the thickness of the coal intercepted in the drill holes, particularly since there is some indication that the dip of the coal flattens down the hole.

TABLE 2 COAL ANALYSES FOR DRILL HOLE 1

| SAMPLE INTERVAL (FEET) | BASIS* | MOISTURE % | VOLATILE MATTER, % | FIXED CARBON, % | ASH % | HEATING VALUE BTU/LB | BASIS: 1-AS RECEIVED 2-EQUILIBRIUM MOISTURE | | | 3-MOISTURE FREE 4-MOISTURE AND ASH FREE | | |
|------------------------------|--------|---------------|-----------------------|--------------------|----------|----------------------------|--|------|------|--|-------------------------|------|
| | | | | | | | C, % | H, % | N, % | O, % | SULFUR PYRITIC TOTAL | |
| 112.5- 123 | 1 | 36.44 | 24.39 | 28.26 | 10.91 | 6377.00 | 38.03 | 6.66 | .69 | 42.71 | .44 | .99 |
| | 2 | 32.59 | 25.87 | 29.97 | 11.57 | 6763.00 | 40.34 | 6.39 | .73 | 39.92 | .47 | 1.05 |
| | 3 | | 38.38 | 44.46 | 17.16 | 10033.00 | 59.84 | 4.07 | 1.08 | 20.35 | .69 | 1.56 |
| | 4 | | 46.33 | 53.67 | | 12111.00 | 72.23 | 4.91 | 1.31 | 19.66 | .84 | 1.89 |
| 123- 126.5 | 1 | 38.73 | 23.97 | 28.32 | 8.98 | 6416.00 | 37.43 | 6.83 | .76 | 45.37 | .03 | .63 |
| | 2 | 29.63 | 27.53 | 32.53 | 10.31 | 7369.00 | 42.99 | 6.19 | .87 | 38.92 | .04 | .72 |
| | 3 | | 39.12 | 46.23 | 14.65 | 10472.00 | 61.09 | 4.08 | 1.24 | 22.00 | .05 | 1.03 |
| | 4 | | 45.83 | 54.17 | | 12270.00 | 71.58 | 4.78 | 1.45 | 20.99 | .06 | 1.20 |
| 132- 141 | 1 | 36.03 | 25.74 | 28.51 | 9.72 | 6692.00 | 38.37 | 6.74 | .04 | 43.72 | .47 | 1.41 |
| | 2 | 28.99 | 28.57 | 31.65 | 10.78 | 7429.00 | 42.60 | 6.25 | .04 | 38.76 | .53 | 1.56 |
| | 3 | | 40.24 | 44.57 | 15.19 | 10461.00 | 59.99 | 4.24 | .06 | 22.56 | .74 | 2.20 |
| | 4 | | 47.45 | 52.55 | | 12335.00 | 70.73 | 4.99 | .07 | 21.61 | .87 | 2.60 |
| 141.0- 150 | 1 | 38.97 | 25.57 | 30.77 | 4.69 | 6949.00 | 40.22 | 7.04 | .74 | 46.51 | .06 | .81 |
| | 2 | 32.24 | 28.39 | 34.16 | 5.20 | 7715.00 | 44.65 | 6.58 | .83 | 41.84 | .06 | .90 |
| | 3 | | 41.90 | 50.42 | 7.68 | 11386.00 | 65.90 | 4.38 | 1.22 | 23.88 | .09 | 1.32 |
| | 4 | | 45.39 | 54.61 | | 12333.00 | 71.38 | 4.75 | 1.32 | 21.12 | .10 | 1.43 |
| 150.0- 160 | 1 | 37.09 | 24.17 | 28.16 | 10.58 | 6493.00 | 37.65 | 6.87 | .59 | 42.81 | .40 | 1.50 |
| | 2 | 28.16 | 27.60 | 32.16 | 12.08 | 7415.00 | 42.99 | 6.26 | .68 | 36.28 | .45 | 1.72 |
| | 3 | | 38.42 | 44.77 | 16.81 | 10322.00 | 59.84 | 4.33 | .94 | 20.02 | .63 | 2.39 |
| | 4 | | 46.18 | 53.82 | | 12407.00 | 71.93 | 5.20 | 1.13 | 18.86 | .76 | 2.87 |
| 160- 170 | 1 | 36.83 | 21.05 | 25.38 | 16.73 | 5607.00 | 33.28 | 6.41 | .70 | 42.12 | .08 | .75 |
| | 2 | 23.55 | 25.48 | 30.72 | 20.25 | 6786.00 | 40.28 | 5.40 | .85 | 32.31 | .10 | .91 |
| | 3 | | 33.33 | 40.18 | 26.49 | 8876.00 | 52.69 | 3.62 | 1.11 | 18.53 | .13 | 1.19 |
| | 4 | | 45.34 | 54.66 | | 12074.00 | 71.67 | 4.93 | 1.51 | 20.27 | .17 | 1.62 |
| 180- 190 | 1 | 37.06 | 26.22 | 30.64 | 6.09 | 7042.00 | 40.10 | 6.83 | .71 | 44.36 | .65 | 1.91 |
| | 2 | 32.40 | 28.16 | 32.91 | 6.54 | 7563.00 | 43.07 | 6.51 | .77 | 41.07 | .69 | 2.05 |
| | 3 | | 41.65 | 48.68 | 9.67 | 11188.00 | 63.72 | 4.26 | 1.13 | 22.45 | 1.03 | 3.03 |
| | 4 | | 46.11 | 53.89 | | 12386.00 | 70.54 | 4.72 | 1.25 | 20.13 | 1.14 | 3.36 |
| 190- 196.5 | 1 | 40.71 | 24.72 | 28.28 | 6.29 | 6592.00 | 38.02 | 7.18 | .70 | 46.82 | .10 | 1.00 |
| | 2 | 33.03 | 27.92 | 31.94 | 7.11 | 7446.00 | 42.94 | 6.66 | .79 | 41.38 | .11 | 1.13 |
| | 3 | | 41.69 | 47.69 | 10.61 | 11119.00 | 64.12 | 4.42 | 1.17 | 22.40 | .17 | 1.69 |
| | 4 | | 46.64 | 53.36 | | 12439.00 | 71.74 | 4.94 | 1.31 | 20.12 | .19 | 1.89 |
| 202.5- 212.5 | 1 | 40.10 | 26.49 | 28.59 | 4.82 | 6940.00 | 39.37 | 7.22 | .70 | 45.92 | .83 | 1.98 |
| | 2 | 33.03 | 29.62 | 31.96 | 5.39 | 7760.00 | 44.01 | 6.75 | .79 | 40.86 | .93 | 2.21 |
| | 3 | | 44.23 | 47.73 | 8.04 | 11587.00 | 65.72 | 4.56 | 1.17 | 21.76 | 1.38 | 3.30 |
| | 4 | | 48.10 | 51.90 | | 12600.00 | 71.47 | 4.96 | 1.28 | 18.71 | 1.50 | 3.59 |
| 212.5- 219.5 | 1 | 43.69 | 24.93 | 26.65 | 4.73 | 6446.00 | 36.76 | 7.40 | .63 | 48.47 | .93 | 2.02 |
| | 2 | 33.67 | 29.37 | 31.39 | 5.57 | 7593.00 | 43.30 | 6.72 | .74 | 41.30 | 1.10 | 2.38 |
| | 3 | | 44.28 | 47.33 | 8.39 | 11448.00 | 65.28 | 4.45 | 1.11 | 21.63 | 1.66 | 3.58 |
| | 4 | | 48.34 | 51.66 | | 12497.00 | 71.26 | 4.86 | 1.22 | 18.75 | 1.81 | 3.91 |

TABLE 3 COAL ANALYSES FOR DRILL HOLE 4

| SAMPLE INTERVAL (FEET) | BASIS* | MOISTURE % | VOLATILE MATTER, % | FIXED CARBON, % | ASH % | HEATING VALUE BTU/LB | TOTAL SULFUR, % |
|------------------------------|--------|---------------|-----------------------|--------------------|----------|----------------------------|--------------------|
| 40.0- 47.5 | 1 | 37.10 | 27.26 | 31.73 | 3.91 | 7109 | .49 |
| | 2 | 31.66 | 29.62 | 34.47 | 4.25 | 7724 | .53 |
| | 3 | | 43.34 | 50.44 | 6.22 | 11302 | .78 |
| | 4 | | 46.21 | 53.79 | | 12053 | .83 |
| 47.5- 51.5 | 1 | 39.45 | 26.88 | 31.15 | 2.52 | 6987 | .64 |
| | 2 | 32.04 | 30.17 | 34.96 | 2.83 | 7843 | .72 |
| | 3 | | 44.39 | 51.44 | 4.17 | 11540 | 1.06 |
| | 4 | | 46.32 | 53.68 | | 12042 | 1.10 |
| 51.5- 57.5 | 1 | 36.31 | 28.58 | 24.83 | 10.29 | 6269 | .59 |
| | 2 | 29.48 | 31.64 | 27.49 | 11.39 | 6942 | .66 |
| | 3 | | 44.87 | 38.98 | 16.15 | 9844 | .93 |
| | 4 | | 53.51 | 46.49 | | 11740 | 1.11 |
| 57.5- 62 | 1 | 41.41 | 25.39 | 30.37 | 2.84 | 6880 | .62 |
| | 2 | 32.80 | 29.12 | 34.83 | 3.25 | 7892 | .71 |
| | 3 | | 43.33 | 51.83 | 4.84 | 11743 | 1.05 |
| | 4 | | 45.53 | 54.47 | | 12341 | 1.11 |
| 62- 68 | 1 | 40.76 | 25.93 | 30.34 | 2.97 | 7017 | .55 |
| | 2 | 31.57 | 29.95 | 35.04 | 3.43 | 8106 | .64 |
| | 3 | | 43.77 | 51.21 | 5.02 | 11845 | .93 |
| | 4 | | 46.08 | 53.92 | | 12471 | .98 |
| 68.0- 73.5 | 1 | 34.19 | 28.43 | 34.26 | 3.12 | 7750 | .73 |
| | 2 | 31.94 | 29.41 | 35.43 | 3.23 | 8015 | .75 |
| | 3 | | 43.20 | 52.05 | 4.74 | 11776 | 1.11 |
| | 4 | | 45.36 | 54.64 | | 12362 | 1.16 |
| 73.5- 80 | 1 | 30.53 | 29.94 | 35.66 | 3.87 | 7992 | .67 |
| | 2 | 31.22 | 29.64 | 35.31 | 3.83 | 7912 | .67 |
| | 3 | | 43.09 | 51.34 | 5.57 | 11504 | .97 |
| | 4 | | 45.64 | 54.36 | | 12182 | 1.03 |
| 80.0- 87 | 1 | 31.23 | 30.66 | 34.74 | 3.37 | 8007 | .65 |
| | 2 | 30.90 | 30.81 | 34.90 | 3.39 | 8046 | .65 |
| | 3 | | 44.59 | 50.51 | 4.90 | 11644 | .94 |
| | 4 | | 46.88 | 53.12 | | 12244 | .99 |
| 87.0- 94.5 | 1 | 30.87 | 29.47 | 34.43 | 5.23 | 7799 | .71 |
| | 2 | 30.46 | 29.64 | 34.64 | 5.26 | 7845 | .71 |
| | 3 | | 42.62 | 49.81 | 7.57 | 11281 | 1.02 |
| | 4 | | 46.11 | 53.89 | | 12205 | 1.11 |

TABLE 3 COAL ANALYSES FOR DRILL HOLE 4 (Continued)

| SAMPLE INTERVAL (FEET) | BASIS* | MOISTURE % | VOLATILE MATTER,% | FIXED CARBON,% | ASH % | HEATING VALUE BTU/LB | TOTAL SULFUR,% |
|------------------------------|--------|---------------|----------------------|-------------------|----------|----------------------------|-------------------|
| 94.5- 101.5 | 1 | 28.99 | 29.68 | 35.42 | 5.91 | 7958 | .56 |
| | 2 | 30.25 | 29.16 | 34.79 | 5.80 | 7817 | .55 |
| | 3 | | 41.80 | 49.88 | 8.32 | 11207 | .79 |
| | 4 | | 45.60 | 54.40 | | 12223 | .87 |
| 101.5- 112 | 1 | 29.61 | 30.14 | 37.11 | 3.14 | 8209 | .66 |
| | 2 | 31.87 | 29.17 | 35.92 | 3.04 | 7946 | .64 |
| | 3 | | 42.81 | 52.73 | 4.46 | 11663 | .94 |
| | 4 | | 44.81 | 55.19 | | 12208 | .98 |
| 112- 118 | 1 | 32.08 | 29.80 | 34.56 | 3.56 | 7959 | .98 |
| | 2 | 32.14 | 29.78 | 34.63 | 3.56 | 7952 | .98 |
| | 3 | | 43.88 | 50.88 | 5.24 | 11719 | 1.45 |
| | 4 | | 46.31 | 53.69 | | 12367 | 1.53 |
| 118- 130 | 1 | 29.04 | 29.07 | 37.75 | 4.13 | 8099 | .67 |
| | 2 | 30.65 | 28.41 | 36.90 | 4.04 | 7915 | .65 |
| | 3 | | 40.97 | 53.20 | 5.82 | 11413 | .94 |
| | 4 | | 43.51 | 56.49 | | 12119 | 1.00 |
| 130.0- 138 | 1 | 28.23 | 30.29 | 37.62 | 3.86 | 8226 | .61 |
| | 2 | 30.23 | 29.45 | 36.57 | 3.75 | 7997 | .59 |
| | 3 | | 42.21 | 52.41 | 5.38 | 11461 | .85 |
| | 4 | | 44.61 | 55.39 | | 12113 | .90 |
| 138.0- 148 | 1 | 30.82 | 29.12 | 36.39 | 3.67 | 7887 | .63 |
| | 2 | 32.05 | 28.60 | 35.74 | 3.61 | 7747 | .62 |
| | 3 | | 42.09 | 52.60 | 5.31 | 11400 | .91 |
| | 4 | | 44.45 | 55.55 | | 12040 | .96 |

*BASIS
 1-AS RECEIVED
 2-EQUILIBRIUM MOISTURE
 3-MOISTURE FREE
 4-MOISTURE AND ASH FREE

TABLE 4 COAL ANALYSES FOR DRILL HOLE 8

| SAMPLE INTERVAL (FEET) | BASIS* | MOISTURE % | VOLATILE MATTER, % | FIXED CARBON, % | ASH % | HEATING VALUE BTU/LB | TOTAL SULFUR, % |
|------------------------------|--------|---------------|-----------------------|--------------------|----------|----------------------------|--------------------|
| 47.0- 54 | 1 | 35.32 | 27.74 | 32.52 | 4.42 | 7411 | 1.15 |
| | 2 | 34.40 | 28.14 | 32.98 | 4.48 | 7516 | 1.16 |
| | 3 | | 42.89 | 50.28 | 6.83 | 11458 | 1.77 |
| | 4 | | 46.04 | 53.96 | | 12297 | 1.90 |
| 54.0- 61 | 1 | 38.07 | 26.73 | 30.46 | 4.75 | 7049 | 1.34 |
| | 2 | 33.86 | 28.54 | 32.53 | 5.07 | 7529 | 1.44 |
| | 3 | | 43.15 | 49.18 | 7.66 | 11383 | 2.17 |
| | 4 | | 46.74 | 53.26 | | 12328 | 2.35 |
| 61.0- 67 | 1 | 34.85 | 27.67 | 32.71 | 4.77 | 7412 | 1.07 |
| | 2 | 33.63 | 28.19 | 33.32 | 4.86 | 7550 | 1.09 |
| | 3 | | 42.47 | 50.21 | 7.32 | 11376 | 1.65 |
| | 4 | | 45.82 | 54.18 | | 12275 | 1.78 |
| 67.0- 72 | 1 | 35.30 | 27.07 | 29.94 | 7.69 | 7037 | 1.07 |
| | 2 | 32.49 | 28.24 | 31.25 | 8.02 | 7342 | 1.11 |
| | 3 | | 41.84 | 46.28 | 11.88 | 10876 | 1.65 |
| | 4 | | 47.48 | 52.52 | | 12342 | 1.87 |
| 72.0- 77 | 1 | 36.59 | 24.16 | 26.53 | 12.71 | 6175 | .74 |
| | 2 | 33.51 | 25.34 | 27.82 | 13.33 | 6475 | .78 |
| | 3 | | 38.10 | 41.85 | 20.05 | 9739 | 1.17 |
| | 4 | | 47.66 | 52.34 | | 12181 | 1.46 |
| 77.0- 83 | 1 | 34.28 | 25.55 | 27.70 | 12.47 | 6471 | .85 |
| | 2 | 33.67 | 25.78 | 27.96 | 12.59 | 6531 | .86 |
| | 3 | | 38.87 | 42.16 | 18.97 | 9846 | 1.29 |
| | 4 | | 47.97 | 52.03 | | 12151 | 1.59 |

*BASIS

- 1-AS RECEIVED
- 2-EQUILIBRIUM MOISTURE
- 3-MOISTURE FREE
- 4-MOISTURE AND ASH FREE

TABLE 5 COAL ANALYSES FOR DRILL HOLE 11

| SAMPLE INTERVAL (FEET) | BASIS* | MOISTURE % | VOLATILE MATTER, % | FIXED CARBON, % | ASH % | HEATING | TOTAL SULFUR, % |
|------------------------------|--------|---------------|-----------------------|--------------------|----------|-----------------|--------------------|
| | | | | | | VALUE BTU/LB | |
| 31.5- 37.5 | 1 | 38.02 | 23.18 | 30.63 | 8.17 | 6527 | .77 |
| | 2 | 32.63 | 25.20 | 33.29 | 8.88 | 7094 | .84 |
| | 3 | | 37.40 | 49.42 | 13.18 | 10530 | 1.24 |
| | 4 | | 43.08 | 56.92 | | 12128 | 1.43 |
| 37.5- 42.5 | 1 | 39.01 | 24.38 | 28.06 | 8.55 | 6326 | 1.15 |
| | 2 | 33.39 | 26.62 | 30.64 | 9.34 | 6909 | 1.25 |
| | 3 | | 39.97 | 46.00 | 14.03 | 10372 | 1.88 |
| | 4 | | 46.49 | 53.51 | | 12065 | 2.18 |
| 42.5- 48 | 1 | 36.93 | 25.44 | 33.18 | 4.45 | 7156 | .82 |
| | 2 | 35.82 | 25.89 | 33.76 | 4.53 | 7282 | .83 |
| | 3 | | 40.34 | 52.60 | 7.06 | 11346 | 1.30 |
| | 4 | | 43.40 | 56.60 | | 12207 | 1.40 |
| 48.0- 53 | 1 | 33.69 | 24.73 | 29.21 | 12.37 | 6482 | .79 |
| | 2 | 31.77 | 25.45 | 30.05 | 12.73 | 6670 | .81 |
| | 3 | | 37.30 | 44.05 | 18.66 | 9776 | 1.18 |
| | 4 | | 45.85 | 54.15 | | 12018 | 1.46 |
| 53.0- 58 | 1 | 37.97 | 24.99 | 31.21 | 5.82 | 6930 | .74 |
| | 2 | 31.53 | 27.59 | 34.46 | 6.43 | 7649 | .82 |
| | 3 | | 40.29 | 50.32 | 9.39 | 11172 | 1.19 |
| | 4 | | 44.47 | 55.53 | | 12329 | 1.31 |
| 58.0- 63 | 1 | 35.24 | 25.49 | 31.66 | 7.61 | 6961 | .71 |
| | 2 | 32.35 | 26.63 | 33.08 | 7.95 | 7271 | .74 |
| | 3 | | 39.36 | 48.89 | 11.75 | 10748 | 1.10 |
| | 4 | | 44.60 | 55.40 | | 12179 | 1.24 |
| 63.0- 68 | 1 | 36.00 | 24.44 | 30.37 | 9.20 | 6621 | .78 |
| | 2 | 31.91 | 26.00 | 32.31 | 9.78 | 7044 | .83 |
| | 3 | | 38.18 | 47.45 | 14.37 | 10345 | 1.22 |
| | 4 | | 44.59 | 55.41 | | 12081 | 1.43 |
| 68.0- 73 | 1 | 33.91 | 26.06 | 29.78 | 10.24 | 6805 | .73 |
| | 2 | 33.25 | 26.33 | 30.08 | 10.34 | 6873 | .74 |
| | 3 | | 39.44 | 45.06 | 15.50 | 10296 | 1.10 |
| | 4 | | 46.67 | 53.33 | | 12185 | 1.31 |
| 73.0- 78 | 1 | 30.46 | 25.22 | 29.95 | 14.37 | 6670 | 1.04 |
| | 2 | 30.00 | 25.39 | 30.15 | 14.47 | 6714 | 1.05 |
| | 3 | | 36.27 | 43.07 | 20.67 | 9591 | 1.50 |
| | 4 | | 45.72 | 54.28 | | 12089 | 1.89 |

*BASIS SAME AS TABLE 3

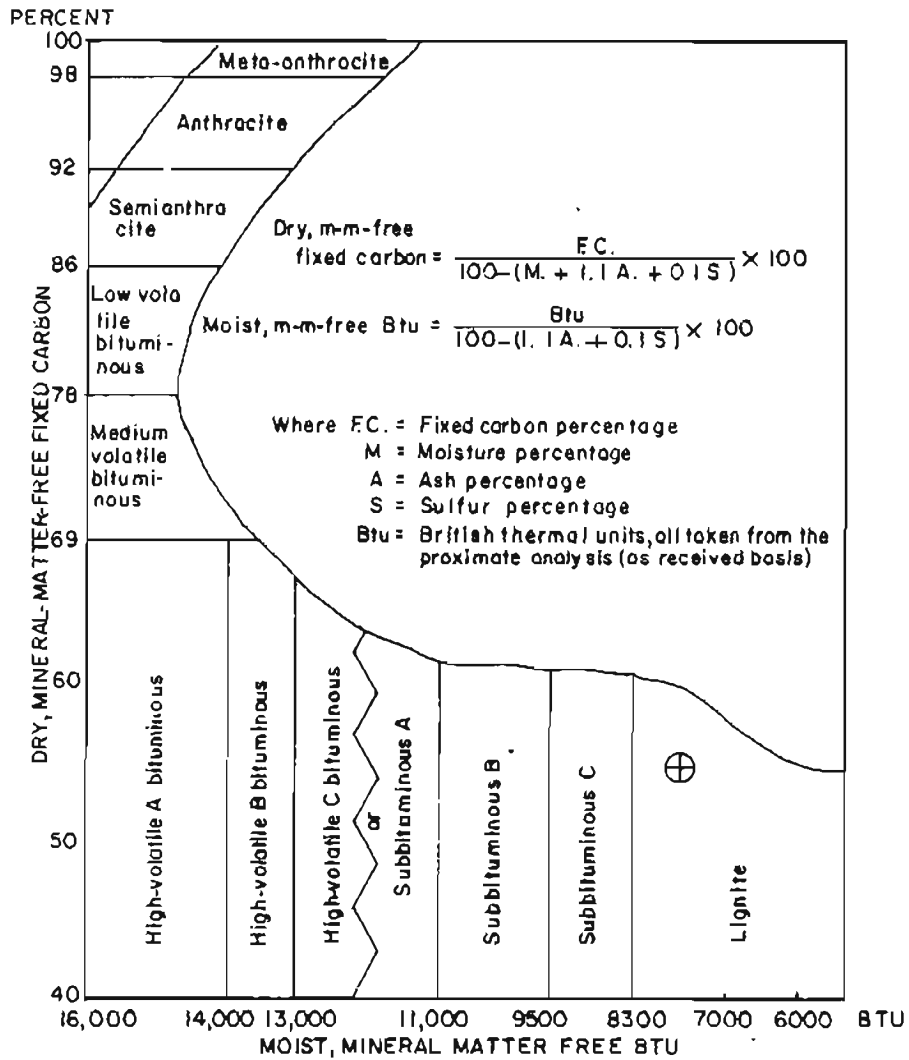
TABLE 6 WEIGHTED AVERAGES FOR PROXIMATE ANALYSES OF DRILL CORE

| DRILL HOLE | BASIS* | MOISTURE % | VOLATILE MATTER, % | FIXED CARBON, % | ASH % | HEATING VALUE BTU/LB | TOTAL SULFUR, % |
|-----------------------------|--------|------------|--------------------|-----------------|-------|----------------------|-----------------|
| 1 | 1 | 38.3 | 24.75 | 28.39 | 8.56 | 6561 | 1.34 |
| | 2 | 30.62 | 27.79 | 31.88 | 9.7 | 7367 | 1.5 |
| | 3 | | 40.19 | 46.06 | 13.74 | 10652 | 2.18 |
| | 4 | | 46.56 | 53.43 | | 12340 | 2.51 |
| 4 | 1 | 32.5 | 28.94 | 34.39 | 4.16 | 7709 | .65 |
| | 2 | 31.22 | 29.51 | 34.99 | 4.27 | 7852 | .66 |
| | 3 | | 42.91 | 50.9 | 6.18 | 11420 | .96 |
| | 4 | | 45.79 | 54.21 | | 12171 | 1.03 |
| 8 | 1 | 35.77 | 26.58 | 30.16 | 7.49 | 6960 | 1.06 |
| | 2 | 33.65 | 27.46 | 31.16 | 7.73 | 7191 | 1.09 |
| | 3 | | 41.39 | 46.97 | 11.63 | 10841 | 1.64 |
| | 4 | | 46.88 | 53.11 | | 12265 | 1.85 |
| 11 | 1 | 35.76 | 24.85 | 30.48 | 8.91 | 6720 | .83 |
| | 2 | 32.55 | 26.1 | 32.03 | 9.32 | 7059 | .87 |
| | 3 | | 38.72 | 47.53 | 13.76 | 10475 | 1.3 |
| | 4 | | 44.93 | 55.07 | | 12143 | 1.51 |
| ----- | | | | | | | |
| AVERAGE FOR ALL DRILL HOLES | 1 | 35.58 | 26.28 | 30.86 | 7.28 | 6987 | .97 |
| | 2 | 32.01 | 27.72 | 32.52 | 7.76 | 7367 | 1.03 |
| | 3 | | 40.8 | 47.87 | 11.33 | 10847 | 1.28 |
| | 4 | | 46.04 | 53.96 | | 12229 | 1.73 |
| ----- | | | | | | | |

*BASIS

- 1-AS RECEIVED
- 2-EQUILIBRIUM MOISTURE
- 3-MOISTURE FREE
- 4-MOISTURE AND ASH FREE

FORMULA FOR APPROXIMATE COAL RANK DETERMINATIONS



⊕ Plot for average of Chicago Creek drill samples

Figure 3. Chart Showing Chicago Creek Coal Rank

Based on the drilling completed during this program, measured resources are approximately 1,000,000 short tons.

Indicated. Indicated resources are geologic projections of outcropping coal beds and drill hole intersections to a depth of 1000 feet and a horizontal distance of 1 mile.

Based on the apparent lateral limits of the coal and the variable thickness shown in the holes, the indicated resources are approximately 6,300,000 short tons.

Inferred. Inferred resources are geologic projections of outcropping coal beds and drill hole intersections to a depth of 3,000 feet and a horizontal distance of 6 miles. Thus, this category is very speculative.

The inferred resource could be as high as 14,600,000 tons.

MINING PLAN

The amended Invitation To Bid included a tentative drilling plan that portrayed ten drill holes each 300 feet deep and arrayed on 1000 foot centers. This plan assumed a flat-lying coal bed. The project specifications required a drill rig capable of drilling a suitable hole 400 feet deep. Because of the uncertainties in the exact location of the coal seam, drill

holes were positioned so that the hole would be sure to intersect both the upper and lower contacts of the coal bed; the deepest hole drilled was 232.5 feet.

Thus if the coal extended deeper than 400 feet, the drilling program would not be capable of determining the reserves.

The selection of the best mining plan is normally made after consideration of numerous factors, some of which are:

- (a) safety,
- (b) cost per ton of coal produced,
- (c) optimum rate of coal production,
- (d) quality of the coal required by the market,
- (e) optimum level of coal recovery,
- (f) ecology and reclamation requirements.

When choosing the actual method of mining, some of the factors to be considered are:

- (a) the nature of the overburden,
- (b) the characteristics of the coal:
 - (1) thickness, dip and lateral extent,
 - (2) nature and location of impurities, irregularities, cleavage, etc.,
 - (3) quantity of explosive gas and water,
 - (4) nature and strength of the footwall and hanging wall formations,

- (5) hardness and structural strength of the coal,
- (6) previous mining;

The basic problem with the Chicago Creek coal as it is presently known, is the 50° to 70° dip. Since the deepest drilling to date is only 232.5 feet, nothing is known about the deeper portion of the coal seam below these drill hole intercepts. With the steep dip, open pit mining soon results in a high stripping ratio, so that the available tonnage which can economically be mined is quite limited. Thus the tonnage of coal that could be economically mined using strip mining methods is not sufficient to justify the expenditure of the funds required to develop a mine mouth power plant and to install power lines to Kotzebue.

The consideration of underground mining methods immediately confronts the problem of the lack of information below the level intersected in the drilling. Insufficient information is available regarding the total reserves, the attitude of the coal seam, its geotechnical characteristics, and the characteristics of the enclosing formations to formulate an underground mining plan.

In summary, a responsible mining plan cannot be developed with the data presently available. Further exploration work must be done to develop sufficient reserves in the "Measured" and "Indicated" categories. Only when adequate reserves are proven

can intelligent planning for the utilization of the energy resource commence.

CONCLUSIONS

The drilling program completed under the contract consisted of 14 drill holes spotted along the surface trend of the coal seam. Structural complications previously unsuspected were found which resulted in less coal being proven than would have been postulated from the previously published data on the coal occurrence.

Substantial portions of the coal seam are 80 feet thick. Areas where the coal was considerably thinner and/or had a very high ash content could indicate that the segment drilled was close to the periphery of the basin. Thus, better quality and thicker coal could exist down dip where there has been no previous exploration.

The results of the program are encouraging. The analytical results on the coal, the confirmation of the thickness of the coal seam, and the strike length of the coal indicate that the quality and potential quantity of the Chicago Creek coal make this deposit an important factor to be considered in the effort to provide low cost power to nearby communities.

This initial drilling program has provided important information that will enable future drilling programs to be designed and executed cost-effectively and technically sound. With adequate funding, the next drilling program will be able to determine if sufficient coal reserves exist at Chicago Creek to be a viable alternative for power generation for the Kotzebue area.

PART II. NORTON SOUND AREA PROJECT

INTRODUCTION

Upon the successful conclusion of the Chicago Creek project, the contract between the State of Alaska and Denali Drilling Inc. was amended to include exploration of four coal occurrences on the north and eastern sides of Norton Sound. These four occurrences were:

- (1) the Coal Creek area south of Unalakleet,
- (2) the Grouse Creek area south of Death Valley,
- (3) the area one mile east of Koyuk,
- (4) the Elim Area.

The exploration work was to consist of surface examination of each occurrence with subsequent drilling if funding permitted. Prior to initiation of the field work, the Grouse Creek examination was deleted from the program because the coal occurrence lies on active mining claims and the owner of the claims felt that active investigation of the coal deposit could jeopardize the future of his uranium deposit. Rather than proceed without the permission of the mining claimant, it was decided to forego examination of this coal occurrence.

LOCATION OF PROJECT SITES

The location of each of the reported Norton Sound area coal occurrences examined is shown on Figure 4.

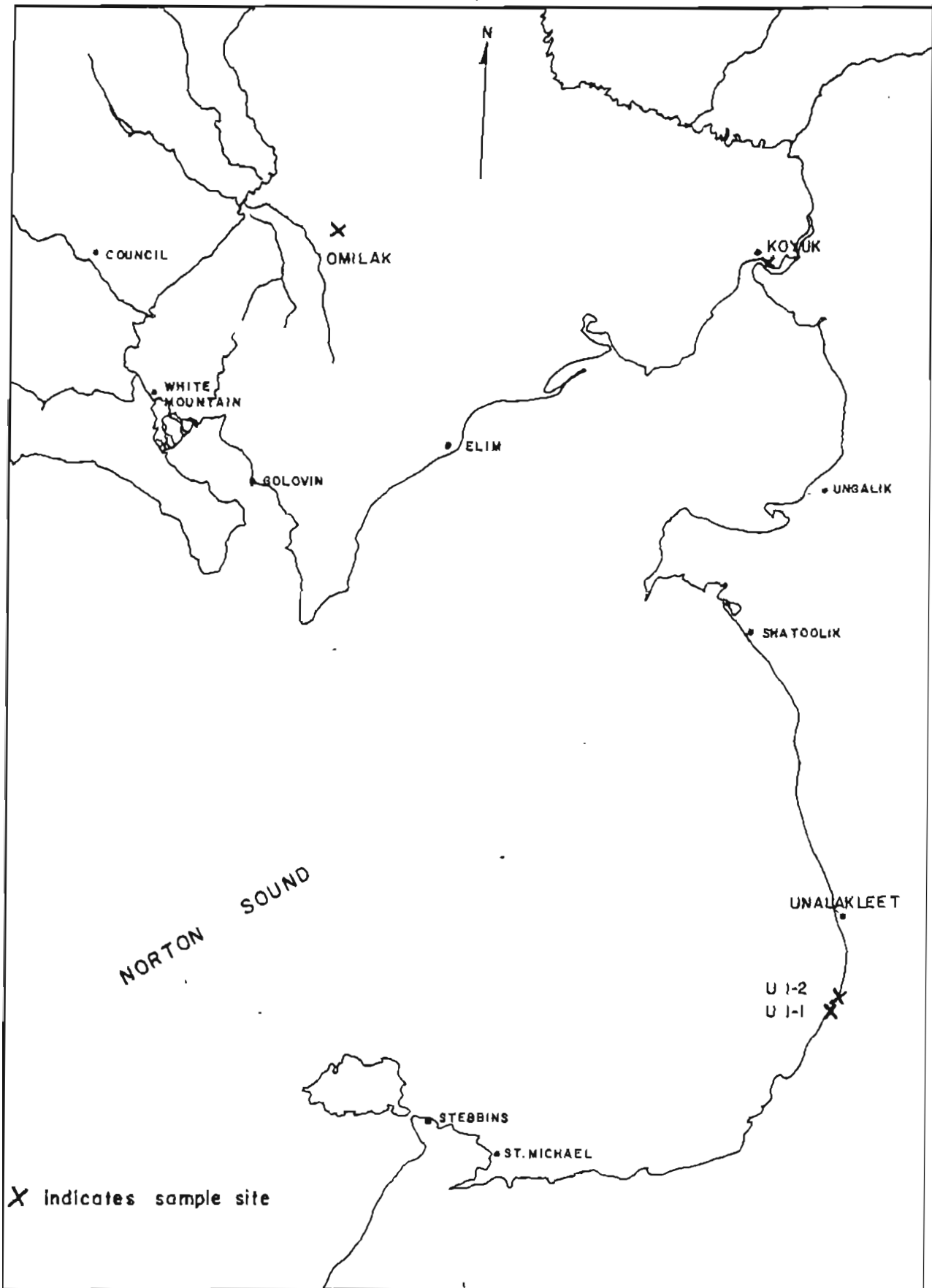


Figure 4. Location of Norton Sound Area Coal Investigation

The actual location of the coal occurrence reported south of Unalakleet was found to be at the mouth of Glacier Creek rather than Coal Creek as these creeks are named on the 1:63,360 topographic map published by the U. S. Geologic Survey. It appears from this discrepancy that the creeks are incorrectly named on the topographic map.

The Koyuk coal occurrence is located about one mile east of the village of Koyuk. Pieces of coal can be found on the beach in close proximity to the source.

The reported coal occurrence near Elim was not found in spite of considerable effort. Black shale was located in the vicinity of the reported coal occurrence leading to speculation that the shale had been incorrectly identified as coal.

The reported coal occurrence on Omilak Creek on the east side of McCarthy's Marsh was not found but a sample was collected for analysis from a gravel bar downstream from the source.

ACCESS TO PROJECT SITES

Access to all the reported coal occurrences was by Bell 206 helicopter. A Cessna 206 was also used for the transportation of men and drilling equipment to the Koyuk site from Unalakleet.

For the work in the Norton Sound area, the base of oper-

ations was established in Unalakleet at the Unalakleet Lodge. The availability of Jet Fuel for the helicopter and fixed wing support when needed made this the ideal location for this portion of the program.

HISTORY AND PRODUCTION

The coal seam at Koyuk is reported to have been mined by one man in the early 1900's. The people living in the nearby village of Koyuk occasionally collect coal for heating requirements from the beach.

Harrington (1919, p. 384) reported that the Koyuk occurrence consisted of a four foot thick seam and a two foot thick seam together with several thinner seams. Total past production has been estimated at approximately 50 tons.

The coal seam south of Unalakleet at Glacier Creek has been reportedly mined at the beachfront level with a timber-supported adit penetrating the coal seam exposed in the sea cliff. The coal seam is reported to be four to eight feet thick (Patton, 1973). Approximately 300 tons of weathered coal were shipped to Nome and St. Michael in 1918, but no major development ever occurred (Cathcart, 1920).

At the mouth of what is called Coal Mine Creek on the topo-

graphic maps, coal seams less than one foot thick occur for a distance of over 1000 feet in the badly slumped bluffs.

REGIONAL GEOLOGY

The coal-bearing units in the Norton Sound area and on the Seward Peninsula are Late Cretaceous to Early Tertiary in age. The coal occurrences at Koyuk and south of Unalakleet are part of a large Tertiary sequence that probably underlies the offshore Norton Basin. The coal occurrences at Grouse Creek and Omilak Creek are in structurally complex and downwarped erosional remnants preserved in downwarped basins.

PROJECT AREA GEOLOGY

Koyuk Area. The coal-bearing unit at Koyuk consists of unconsolidated silt, sand and clay. Cass (1959) placed this unit in the Cretaceous Shaktoolik Group. The test drilling indicated that a one to two foot thick coal seam has a strike of N 55° E with a dip of 20 to 30 ° S. At the deposit location, the seam abruptly swells out to a four foot seam and a two foot thick seam. Permafrost is discontinuous on the beach and is probably more pervasive farther away from the water.

Unalakleet Area. The coal occurrences south of Unalakleet are found in flat-lying Early Tertiary shales. The actual site of the mining which produced the coal shipped to Nome and St. Michael was not recognizable. A basic geologic mapping program

is needed in this area and must be included in any future exploration of the coal deposits in this area.

DRILLING METHODS

A Minute-Man portable drill with three inch solid flite auger was used to drill and sample the Koyuk coal occurrence. The drill holes were located as shown on Figure 5, Location of Koyuk Drill Holes. Twenty two holes were drilled to an average depth of about 20 feet. Samples were taken from the auger cuttings for analysis. The analytical data is presented in Tables 7 and 8. A lithologic log was made of each hole. These logs are presented in Appendix D. Figures 6 and 7 are photographs of the drilling operations at Koyuk.

COAL ANALYSIS METHODS AND RESULTS

All coal samples collected during this portion of the project were submitted to the Mineral Industry Research Laboratory at the University of Alaska in Fairbanks, Alaska. The samples were analyzed by standard ASTM methods under the supervision of Dr. P. Dharma Rao, Professor of Coal Technology.

Coal samples from the coal-bearing sections of Koyuk drill holes 1, 3, 4, 8, 9, 15, 17, 18, 19, and 22 were analyzed. A sample of coal collected from a river bar downstream from the South Umilak Creek and two samples collected from the coal-bearing formations south of Unalakleet were also analyzed. The

○ TH-1

⊗ Adit

Legend

- Drill Hole with No Coal
- ⊕ Drill Hole with Coal up to 1' thick
- ⊗ Drill Hole with Coal 1' to 1.9' thick
- Drill Hole with Coal $\geq 2.0'$ thick

Scale 1" = 50'

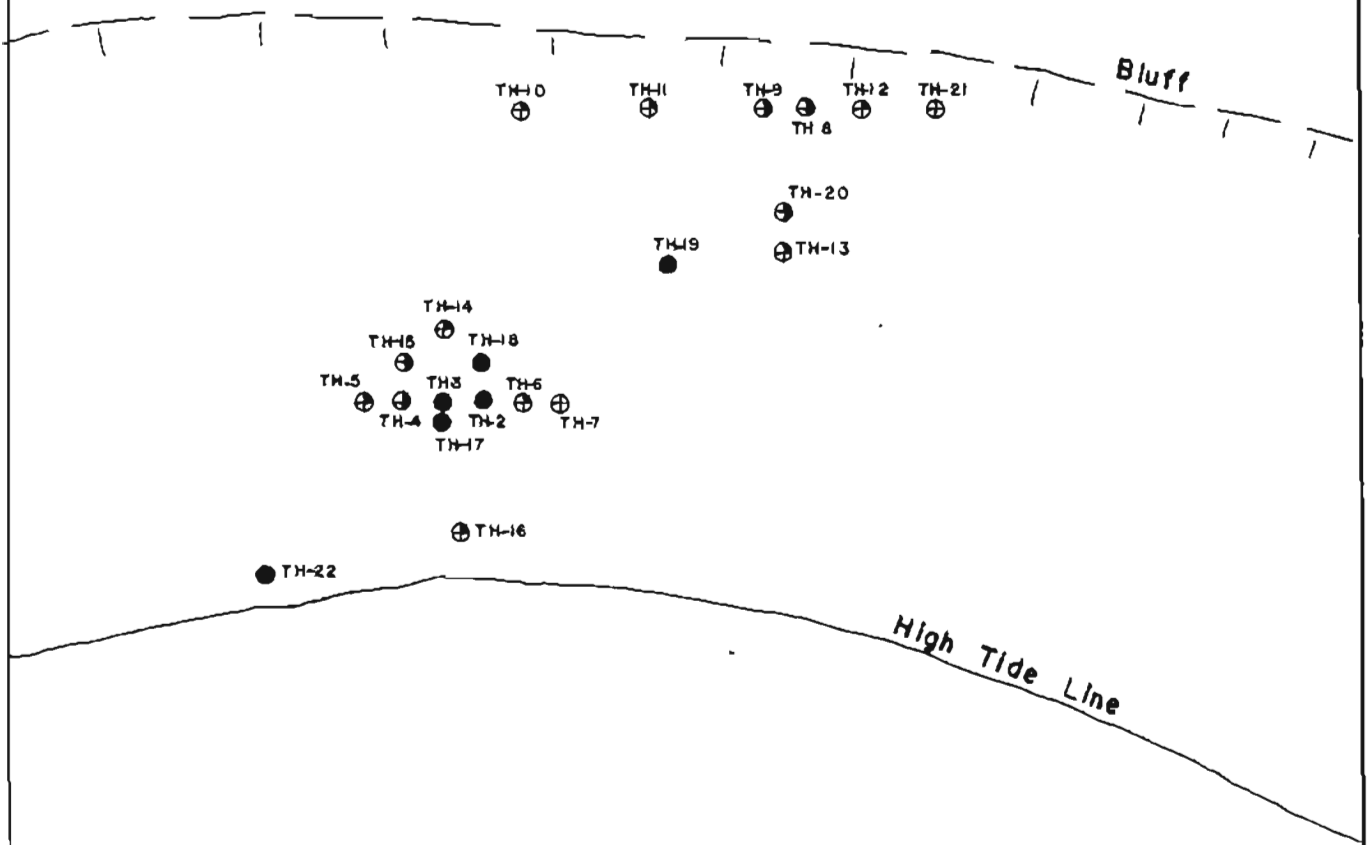


Figure 5. Location of Koyuk Drill Holes

TABLE 7 PROXIMATE ANALYSES OF NORTON SOUND AREA SAMPLES

| DRILL HOLE AND INTERVAL (FEET) | BASIS* | MOISTURE % | VOLATILE MATTER, % | FIXED CARBON, % | ASH % | HEATING VALUE BTU/LB | TOTAL SULFUR, % |
|---|--------|---------------|-----------------------|--------------------|----------|----------------------------|--------------------|
| TH-1 9.0'-13.0' | 2 | 22.25 | 29.25 | 40.24 | 8.27 | 8459 | 0.30 |
| | 3 | | 37.62 | 51.75 | 10.63 | 10880 | 0.38 |
| | 4 | | 42.09 | 57.91 | | 12174 | 0.42 |
| TH-3 6.0'-10.0' | 2 | 21.43 | 29.55 | 41.43 | 7.58 | 8641 | 0.28 |
| | 3 | | 37.61 | 52.73 | 9.65 | 10998 | 0.36 |
| | 4 | | 41.63 | 58.37 | | 12173 | 0.39 |
| TH-3 11.0'-13.0' | 2 | 20.65 | 29.22 | 40.91 | 9.22 | 8567 | 0.28 |
| | 3 | | 36.82 | 51.56 | 11.62 | 10796 | 0.36 |
| | 4 | | 41.66 | 58.34 | | 12215 | 0.40 |
| TH-4 6.0'-9.5' | 2 | 23.11 | 29.25 | 36.85 | 10.79 | 7836 | 0.47 |
| | 3 | | 38.05 | 47.92 | 14.03 | 10191 | 0.61 |
| | 4 | | 44.26 | 55.74 | | 11854 | 0.71 |
| TH-8 15'-16' | 2 | 20.73 | 29.19 | 38.10 | 11.99 | 8267 | 0.42 |
| | 3 | | 36.82 | 48.06 | 15.12 | 10429 | 0.53 |
| | 4 | | 43.38 | 56.62 | | 12287 | 0.62 |
| TH-9 15'-18' | 2 | 21.56 | 29.95 | 38.09 | 10.40 | 8102 | 0.44 |
| | 3 | | 38.18 | 48.56 | 13.26 | 10329 | 0.56 |
| | 4 | | 44.02 | 55.98 | | 11908 | 0.65 |
| TH-15 9'-10' | 2 | 21.65 | 28.37 | 40.58 | 9.40 | 8393 | 0.43 |
| | 3 | | 36.21 | 51.79 | 12.00 | 10712 | 0.55 |
| | 4 | | 41.15 | 58.85 | | 12172 | 0.62 |
| TH-17 8.0'-12.5' | 2 | 21.96 | 29.66 | 40.39 | 7.99 | 8502 | 0.32 |
| | 3 | | 38.01 | 51.76 | 10.24 | 10895 | 0.41 |
| | 4 | | 42.34 | 57.66 | | 12137 | 0.46 |
| TH-17 12.5'-15.0' | 2 | 21.62 | 29.80 | 40.49 | 8.10 | 8311 | 0.31 |
| | 3 | | 38.02 | 51.65 | 10.33 | 10946 | 0.40 |
| | 4 | | 42.40 | 57.60 | | 12207 | 0.45 |
| TH-17 15.0'-21.0' | 2 | 21.18 | 29.97 | 40.94 | 7.91 | 8647 | 0.31 |
| | 3 | | 38.03 | 51.94 | 10.04 | 10970 | 0.39 |
| | 4 | | 42.27 | 57.73 | | 12194 | 0.43 |

TABLE 7 PROXIMATE ANALYSES OF NORTON SOUND AREA SAMPLES (Continued)

| DRILL HOLE AND INTERVAL (FEET) | BASIS* | MOISTURE % | VOLATILE MATTER, % | FIXED CARBON, % | ASH % | HEATING VALUE BTU/LB | TOTAL SULFUR, % |
|---|--------|---------------|-----------------------|--------------------|----------|----------------------------|--------------------|
| TH-18 8.0'-12.0' | 2 | 21.35 | 29.41 | 40.98 | 8.26 | 8561 | 0.31 |
| | 3 | | 37.40 | 52.10 | 10.50 | 10885 | 0.40 |
| | 4 | | 41.79 | 58.21 | | 12163 | 0.45 |
| TH-19 15.5'-17.5' | 2 | 22.39 | 28.93 | 37.95 | 10.73 | 8017 | 0.40 |
| | 3 | | 37.27 | 48.90 | 13.83 | 10330 | 0.52 |
| | 4 | | 43.25 | 56.75 | | 11987 | 0.60 |
| TH-22 2.0'-2.5' | 2 | 23.47 | 29.27 | 37.77 | 9.49 | 7775 | 0.31 |
| | 3 | | 38.25 | 49.35 | 12.40 | 10159 | 0.40 |
| | 4 | | 43.66 | 56.34 | | 11598 | 0.46 |
| KOYUK PIT SPL | 2 | 21.43 | 28.93 | 40.70 | 8.94 | 8497 | 0.39 |
| | 3 | | 36.82 | 51.80 | 11.38 | 10815 | 0.49 |
| | 4 | | 41.55 | 58.45 | | 12204 | 0.56 |
| KOYUK II-1 | 2 | 21.28 | 31.23 | 42.10 | 5.39 | 8885 | 0.45 |
| | 3 | | 39.67 | 53.48 | 6.85 | 11287 | 0.57 |
| | 4 | | 42.59 | 57.41 | | 12117 | 0.61 |
| SOUTH UMILAK | 2 | 24.28 | 41.75 | 28.49 | 5.48 | 7663 | 0.97 |
| | 3 | | 55.14 | 37.63 | 7.24 | 10120 | 1.28 |
| | 4 | | 59.44 | 40.56 | | 10909 | 1.38 |
| UNALAKLEET I-1 | 2 | 20.89 | 32.77 | 30.45 | 15.89 | 7348 | 0.35 |
| | 3 | | 41.43 | 38.49 | 20.08 | 9288 | 0.44 |
| | 4 | | 51.84 | 48.16 | | 11622 | 0.55 |
| UNALAKLEET I-2 | 2 | 21.49 | 35.77 | 31.35 | 11.40 | 8044 | 0.39 |
| | 3 | | 45.56 | 39.93 | 14.52 | 10246 | 0.50 |
| | 4 | | 53.29 | 46.71 | | 11986 | 0.59 |

BASIS 2-EQUILIBRIUM MOISTURE
 3-MOISTURE FREE
 4-MOISTURE AND ASH FREE

TABLE 8 ULTIMATE ANALYSES OF NORTON SOUND AREA SAMPLES

| DRILL HOLE AND INTERVAL (FEET) | BASIS* | C, % | H, % | N, % | O, % | PYRITIC SULFUR, % |
|---|-------------------------|-------|------|------|-------|----------------------|
| TH-17 8.0'-12' | 2 | 50.05 | 5.75 | 0.68 | 35.20 | 0.03 |
| | 3 | 64.14 | 4.22 | 0.88 | 24.34 | 0.03 |
| | 4 | 71.45 | 4.71 | 0.98 | 22.41 | 0.04 |
| TH-17 12.5'-15.0 | 2 | 50.03 | 5.64 | 0.70 | 35.23 | 0.03 |
| | 3 | 63.83 | 4.11 | 0.89 | 24.56 | 0.03 |
| | 4 | 71.18 | 4.58 | 0.99 | 22.80 | 0.04 |
| TH-17 15.0'-21.0 | 2 | 50.79 | 5.62 | 0.66 | 34.72 | 0.03 |
| | 3 | 64.44 | 4.12 | 0.83 | 24.30 | 0.03 |
| | 4 | 71.63 | 4.58 | 0.93 | 22.43 | 0.04 |
| KOYUK PIT SPL | 2 | 50.31 | 5.59 | 0.67 | 34.11 | 0.02 |
| | 3 | 64.03 | 4.06 | 0.85 | 23.24 | 0.02 |
| | 4 | 72.26 | 4.58 | 0.96 | 21.65 | 0.03 |
| BASIS | 2-EQUILIBRIUM MOISTURE | | | | | |
| | 3-MOISTURE FREE | | | | | |
| | 4-MOISTURE AND ASH FREE | | | | | |

analytical data for these samples is presented in Tables 7 and 8.

Since the drill holes were very shallow and the other samples collected were taken from surface exposures, these data must be recognized as having been affected by weathering.

COAL RESOURCES

The level of funding and the work performed on the Norton Sound area portion of the program does not allow calculation of the available coal resources. The objective of this work was to develop sufficient data so that the exploration work to be done in these areas in 1983 could be properly planned and executed.

CONCLUSIONS

The field work completed indicates that coal apparently exists in sufficient quantity near both Koyuk and Unalakleet to warrant further exploration. Energy self-sufficiency is a worthwhile goal for villages in remote areas and the development of the coal resources near these two villages will be a major step towards that goal.

APPENDIX A
CHICAGO CREEK DRILL HOLE LOGS

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record

HOLE NO. DH-1-82

Location: 1+52.9 S, 0+21 W, BL I **Property:** Chicago Creek

Elevation: 186.2 feet **From:** **To:**

Azimuth: Vertical **Non-Core:** 0' 90'

Dip: 90° **Cored:** 90' 232.5'

Length: 232.5' T.D. **Non-core hole size:** 4.75 inches

Started: 7/28/82 **Core size:** 2 3/8 inches

Completed: 7/30/82 **Non-core bit type:** Tricone

Logged: Lithologic **Core bit type:** Step face impreg.

Logged by: K.H. Manning **Core barrel type:** Split Sleeve

Hole Probed: N/A **Drill type:** Longyear 38

Logs Run: N/A **Fluids used:** Minex 1330 Polymer

Drilling Contractor: Denali Drilling Inc.

Geological Contractor: Stevens Exploration Management Corp.

Logging Contractor: N/A

| Graphic | From | To | Description | % Recov. |
|---------|------|-----|--|--------------------------|
| | 0.0 | | OVERBURDEN: 0 to 40'; frozen silt and silt-clay mixtures; occasional lenses of massive ice | Tricone no core 0 to 90' |
| | 25' | | 28.5' to 30'-cobbles | |
| | | 40' | 30' to 40' - coal fragments | |
| | | | COAL: 40' to 223.3'; dull brown-black in color | |
| | 50' | | percentage of coal fragments in cuttings increases downwards to 90' | |
| | 75' | | | |
| | 90' | | 90' to 110'- thin clay seams | CORING |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record

HOLE NO. DH-1

PAGE NO. 2 of 2

| Graphic | From | To | Description | % Recov. |
|---------|------|----|---|----------|
| | 100' | | COAL:same as above | |
| | | | | 10% |
| | | | highly fractured, only "gravel" recovered | 10% |
| | | | occasional 4"-6" solid pieces, | 86% |
| | 125' | | 10% bright bands, bedding angle to core- 65° - 70° | 88% |
| | | | Numerous partings with traces of clay | 32% |
| | | | | 63% |
| | | | | 2% |
| | 150' | | | 38% |
| | | | bedding angle to core - 68° | 16% |
| | | | 70°; 1/8" to 3/8" bright bands | |
| | | | average 20% to 30%; highly fractured; Trace of pyrite along bedding plane/joint surfaces. | 1% |
| | 175' | | | 23% |
| | | | Occasional clayey bands and beds | 75% |
| | | | Bright bands decrease to 10-15% | 98% |
| | 200' | | | 14% |
| | | | | 14% |
| | | | COAL bottoms at 223.3' | |
| | 225' | | CLAY with silt and increasing amounts of cobbles and boulders with depth. T.D. 232.5" | 57% |
| | | | | 17% |
| | 250' | | | |
| | | | | |
| | 275' | | | |
| | | | | |
| | 300' | | | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record HOLE NO. DH-2-82

Location: 11+97.5 S, 00 W, BL I **Property:** Chicago Creek

Elevation: 248.9' **From:** **To:**

Azimuth: Vertical **Non-Core:** 18.0' 105.0'

Dip: 90° **Cored:** 0.0' 18.0'

Length: 105.0' T.D. **Non-core hole size:** 4.5 inches

Started: 7/31/82 **Core size:** HX (2.5")

Completed: 8/1/82 **Non-core bit type:** Tricone

Logged: Lithologic **Core bit type:** Step face impreg.

Logged by: K. H. Manning **Core barrel type:** Split tube

Hole Probed: N/A **Drill type:** Longyear 38

Logs Run: N/A **Fluids used:** Minex 1330 Polymer

Drilling Contractor: Denali Drilling Inc.

Geological Contractor: Stevens Exploration Management Corp.

Logging Contractor: N/A

| Graphic | From | To | Description | % Recov. |
|---------|------|-----|--|-----------------|
| | 0.0' | | OVERBURDEN: 0.0' to 72'; frozen silt with some clay | Cored 14% |
| | | | 15' to 17'-sand and gravel | 100% |
| | | | 17' to 32'-clay | Tricone to T.D. |
| | 25' | | 32' to 72'-silt with gravel and sand; increasing percentage of rock fragments to 72' | |
| | 50' | | | |
| | 72' | 72' | SCHIST: weathered graphitic schist with trace of pyrite and 5% quartz | |
| | 90' | | | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record

HOLE NO. DH-2-82
PAGE NO. 2 of 2

| Graphic | From | To | Description | % Recov. |
|---------|------|------|-----------------|----------|
| | 100' | | SCHIST:as above | Tricone |
| | | 105' | T. D. at 105.0' | |
| | 125' | | | |
| | 150' | | | |
| | 175' | | | |
| | 200' | | | |
| | 225' | | | |
| | 250' | | | |
| | 275' | | | |
| | 300' | | | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record HOLE NO. DH-3-82

| | |
|--|---|
| Location: 6+68.6 S, 00 W, BL I | Property: Chicago Creek |
| Elevation: 236.7' | From: To: |
| Azimuth: Vertical | Non-Core: 0.0' 30.0' |
| Dip: 90° | Cored: 30.0' 32' |
| Length: 32.0' T.D. | Non-core hole size: 3 7/8" |
| Started: 8/3/82 | Core size: HX (2.5") |
| Completed: 8/4/82 | Non-core bit type: Tricone |
| Logged: Lithologic | Core bit type: Step face impreg. |
| Logged by: K. H. Manning | Core barrel type: Split tube |
| Hole Probed: N/A | Drill type: Longyear 38 |
| Logs Run: N/A | Fluids used: Minex 1330 Polymer |
| Drilling Contractor: Denali Drilling Inc. | |
| Geological Contractor: Stevens Exploration Management Corp. | |
| Logging Contractor: N/A | |

| Graphic | From | To | Description | % Recov. |
|---------|------|-----|--|----------|
| | 0.0 | | OVERBURDEN: 0.0' to 19.0'; frozen silt with some sand | Tricone |
| | | 19' | 14' to 19'-sand and gravel QUARTZITE: very hard | |
| | 19' | | | Core |
| | | 32' | T. D. 32' | 2% |
| | 50' | | | |
| | 75' | | | |
| | 90' | | | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record HOLE NO. DH-4-82

Location: 3+64 S, 22+0 W, BL I Property: Chicago Creek

Elevation: 212'

From: 0.0 To: 62'

Azimuth: Vertical

Non-Core: 135' 230'

Dip: 90°

Cored: 62' 135'

Length: 230.0' T.D.

Non-core hole size: 3 7/8"

Started: 8/4/82

Core size: HX (2.5")

Completed: 8/10/82

Non-core bit type: Tricone

Logged: Lithologic

Core bit type: Step face impreg.

Logged by: K. H. Manning

Core barrel type: Split tube

Hole Probed: N/A

Drill type: Longyear 38

Logs Run: N/A

Fluids used: Minex 1330 Polymer

Drilling Contractor: Denali Drilling Inc.

Geological Contractor: Stevens Exploration Management Corp.

Logging Contractor: N/A

| Graphic | From | To | Description | % Recov. |
|---------|------|-----|---|-----------|
| | 0.0 | | OVERBURDEN: 0.0' to 38'; frozen silt with some clay and up to 50% ice | Tricone |
| | 25' | | | |
| | | 38' | | |
| | 38' | | COAL: 38' to 217'; very broken; partings have 1/8" to 3/8" clay beds; bedding angle to core is 65° to 70°; pyrite coatings on fractures; to 63', 10% bright bands | Core 100% |
| | 50' | | | 100% |
| | | | | 100% |
| | 75' | | | 75% |
| | | | | 98% |
| | 90' | | | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record

HOLE NO. DH-4-82
PAGE NO. 2 of 2

| Graphic | From | To | Description | % Recov. |
|---------|------|------|--|----------------------|
| | 100' | | at 95', bright bands increase to 15% to 20% | 100% |
| | | | numerous partings 1/8" to 3/8" thick | 100% |
| | | | 4" clay bed at 114'; bright bands average 10% to 15% | 65% |
| | 125' | | bright bands increase - 25% to 35% | 30% |
| | | | bedding angle to core - 72° | 83% |
| | | | Tricone cuttings indicate coal is continuous to 217' | 100% |
| | 150' | | | 50% |
| | | | | 42% |
| | | | | Tricone rest of hole |
| | 175' | | | |
| | 200' | | | |
| | 217' | 217' | CLAY: 217' to 230' | |
| | 225' | 230' | T.D. 230' | |
| | 250' | | | |
| | 275' | | | |
| | 300' | | | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record HOLE NO. DH-5-82

Location: 7+12 S, 1+03 W, BL I **Property:** Chicago Creek

Elevation: 244.9' **From:** **To:**

Azimuth: Vertical **Non-Core:** 0.0' 65.0'

Dip: 90° **Cored:**

Length: 65.0' T.D. **Non-core hole size:** 3 7/8"

Started: 8/11/82 **Core size:** HX (2.5")

Completed: 8/13/82 **Non-core bit type:** Tricone

Logged: Lithologic **Core bit type:** Step face impreg.

Logged by: K. H. Manning **Core barrel type:** Split tube

Hole Probed: N/A **Drill type:** Longyear 38

Logs Run: N/A **Fluids used:** Quik-Gel

Drilling Contractor: Denali Drilling Inc.

Geological Contractor: Stevens Exploration Management Corp.

Logging Contractor: N/A

| Graphic | From | To | Description | % Recov. |
|---------|------|-----|--|----------|
| | 0.0 | | OVERBURDEN:0.0' TO 44.0'; frozen silt with some sand | TRICONE |
| | 25' | | | |
| | | 44' | | |
| | 44' | | QUARTZ-MICA-SCHIST:44' to 65' | |
| | | 65' | T. D. 65' | |
| | 75' | | | |
| | 90' | | | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record HOLE NO. DH-6-82

Location: 5+08 N, 00 W, BL II **Property:** Chicago Creek

Elevation: 153' **From:** **To:**

Azimuth: Vertical **Non-Core:** 0.0' 200.0'

Dip: 90° **Cored:**

Length: 200.0 T.D. **Non-core hole size:** 3 7/8"

Started: 8/13/82 **Core size:** HX (2.5")

Completed: 8/17/82 **Non-core bit type:** Tricone

Logged: Lithologic **Core bit type:** Step face impreg.

Logged by: K. H. Manning **Core barrel type:** Split tube

Hole Probed: Yes **Drill type:** Longyear 38

Logs Run: Gamma, Density **Fluids used:** Quik Gel

Drilling Contractor: Denali Drilling Inc.

Geological Contractor: Stevens Exploration Management Corp.

Logging Contractor: Geo-Recon International, Ltd.

| Graphic | From | To | Description | % Recov. |
|---------|------|-----|--|------------------|
| | 0.0 | | OVERBURDEN: 0.0'-34'; frozen silt with some clay | Tricone to T. D. |
| | | | gravel and cobbles at 12' to 13' | |
| | 25' | | | |
| | | 34' | coal fragments start at 28.0' | |
| | 34' | | COAL: has interbedded clay beds up to 10" in thickness | |
| | 50' | | | |
| | | | | |
| | | | | |
| | 75' | | | |
| | | | | |
| | 90' | | | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record

HOLE NO. DH-6-82

PAGE NO. 2 of 2

| Graphic | From | To | Description | % Recov. |
|---------|------|------|----------------------------------|----------|
| | 100' | | COAL: | |
| | 125' | | | |
| | 150' | | | |
| | 175' | | | |
| | 190' | 190' | bottom of Coal | |
| | 200' | | Quartz-graphite-SCHIST:190'-200' | |
| | | | T.D. at 200' | |
| | 225' | | | |
| | 250' | | | |
| | 275' | | | |
| | 300' | | | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record HOLE NO. DH-7-82

Location: 26+40 N, 0+76.7 E, BL II **Property:** Chicago Creek

Elevation: 231' **From:** **To:**
Azimuth: Vertical **Non-Core:** 0.0' 130.0'

Dip: 90° **Cored:** None

Length: 130.0' T.D. **Non-core hole size:** 3 7/8"

Started: 8/17/82 **Core size:**

Completed: 8/18/82 **Non-core bit type:** Tricone

Logged: Lithologic **Core bit type:**

Logged by: K. H. Manning **Core barrel type:** Split tube

Hole Probed: 8/19/82 **Drill type:** Longyear 38

Logs Run: Gamma, Density **Fluids used:** Quik Gel, Quik Trol

Drilling Contractor: Denali Drilling Inc.

Geological Contractor: Stevens Exploration Management Corp.

Logging Contractor: Geo-Recon International Ltd.

| Graphic | From | To | Description | % Recov. |
|---------|------|------|--|----------|
| | 0.0 | | OVERBURDEN:0.0' to 36.0'; silt with 10% to 40% ice | Tricone |
| | 25' | | | |
| | | 36.0 | | |
| | 36' | | COAL:36.0' to 80.0';less than 10% bright bands in cuttings | |
| | 50' | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | 75' | | | |
| | | 80' | Bottom of Coal | |
| | 80' | | CLAY:green clay to 100' | |
| | 90' | | | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record

HOLE NO. DH-7-82
PAGE NO. 2 of 2

| Graphic | From | To | Description | % Recov. |
|---------|------|------|--------------------|----------|
| | 100' | 100' | Decomposed bedrock | Tricone |
| | 125' | 130' | T. D. 130' | |
| | 150' | | | |
| | 175' | | | |
| | 200' | | | |
| | 225' | | | |
| | 250' | | | |
| | 275' | | | |
| | 300' | | | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record HOLE NO. DH-8-82

Location: 31+44 N, 1+36 E, BL II **Property:** Chicago Creek

Elevation: 270' **From:** **To:**

Azimuth: Vertical **Non-Core:** 0' 47'

Dip: 90° **Cored:** 47' 92'

Length: 92' T.D. **Non-core hole size:** 4.5"

Started: 8/18/82 **Core size:** HX (2.5")

Completed: 8/19/82 **Non-core bit type:** Tricone

Logged: Lithologic **Core bit type:** Step face impreg.

Logged by: K. H. Manning **Core barrel type:** Split tube

Hole Probed: 8/19/82 **Drill type:** Longyear 38

Logs Run: Gamma, Density **Fluids used:** Quik Gel

Drilling Contractor: Denali Drilling Inc.

Geological Contractor: Stevens Exploration Management Corp.

Logging Contractor: Geo-Recon International Ltd.

| Graphic | From | To | Description | % Recov. |
|---------|------|-----|--|-----------|
| | 0.0 | | OVERBURDEN: 0.0' to 47'; silt with 10% to 50% ice | TRICONE |
| | 25' | | | |
| | 47' | 47' | COAL: 47' TO 83'; bright bands 5% to 10%; silt layers 1/2" to 2" thick, bedding angle to core 50-55°, thoroughly fractured | Cored 72% |
| | 75' | 83' | 73' to 75' 10% to 15% silt Bottom of Coal @ 83' | 80% |
| | 90' | | CLAY: 83' to 92'; T. D. 92.0' | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record HOLE NO. DH-9-82

Location: 41+92 N, 1+86 E, BL II **Property:** Chicago Creek

Elevation: 326' **From:** **To:**

Azimuth: Vertical **Non-Core:** 0' 70'

Dip: 90° **Cored:** NONE

Length: 70.0' T.D. **Non-core hole size:** 4.5"

Started: 8/19/82 **Core size:** HX (2.5")

Completed: 8/29/82 **Non-core bit type:** Tricone

Logged: Lithologic **Core bit type:** Step face impreg.

Logged by: K. H. Manning **Core barrel type:** Split tube

Hole Probed: 8/27/82 **Drill type:** Longyear 38

Logs Run: gamma, density **Fluids used:** Quik Gel

Drilling Contractor: Denali Drilling Inc.

Geological Contractor: Stevens Exploration Management Corp.

Logging Contractor: Geo-Recon International Ltd.

| Graphic | From | To | Description | % Recov. |
|---------|------|-----|--|----------|
| | 0.0 | | OVERBURDEN: 0' to 47'; Silt with 10% to 40% ice; 10% to 20% sand, less than 10% clay | Tricone |
| | 25' | | | |
| | | 47' | COAL: 47' to 52'; bedding angle to core 40-50° | |
| | 50' | | | |
| | 52' | | CLAY: light gray, less than 10% silt | |
| | | 70' | T.D. 70' | |
| | 75' | | | |
| | 90' | | | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record HOLE NO. DH-10-82

Location: 15+87 N, 0+75 W, BL II **Property:** Chicago Creek

Elevation: 178' **From:** **To:**

Azimuth: Vertical **Non-Core:** 0 15'

Dip: 90° **Cored:** 15' 115'

Length: 115' T. D. **Non-core hole size:** 4.5"

Started: 8/30/82 **Core size:** HX (2.5")

Completed: 8/31/82 **Non-core bit type:** Tricone

Logged: Lithology **Core bit type:** Step face impreg.

Logged by: Clyde Ringstad **Core barrel type:** Split tube

Hole Probed: 9/1/82 **Drill type:** Longyear 38

Logs Run: Gamma, Density **Fluids used:** Quik Gel

Drilling Contractor: Denali Drilling Inc.

Geological Contractor: Stevens Exploration Management Corp.

Logging Contractor: Geo-Recon International Ltd.

| Graphic | From | To | Description | % Recov. |
|---------|------|------|---|----------|
| | 0.0 | | OVERBURDEN: 0' to 15': Silt with 10% to 40% ice | Tricone |
| | | 15' | | Cored |
| | | 20' | COAL fragments: 15' to 20' | |
| | 25' | | SCHIST: 20' to 115': | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | 50' | | | |
| | | | | |
| | | | | |
| | | | | |
| | 75' | | | |
| | | | | |
| | | | | |
| | 90' | 115' | T. D. 115' | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record HOLE NO. DH-11-82

Location: 12+37' N, 00 W, BL II **Property:** Chicago Creek

Elevation: 168' **From:** **To:** 31.5'

Azimuth: Vertical **Non-Core:** 88' 98'

Dip: 90° **Cored:** 31.5' 88'

Length: 98' T.D. **Non-core hole size:** 4.5"

Started: 8/31/82 **Core size:** HX (2.5")

Completed: 9/1/82 **Non-core bit type:** Tricone

Logged: Lithology **Core bit type:** Surface set

Logged by: Clyde Ringstad **Core barrel type:** Split tube

Hole Probed: 9/3/82 **Drill type:** Longyear 38

Logs Run: Gamma, Density **Fluids used:** Quik Gel

Drilling Contractor: Denali Drilling Inc.

Geological Contractor: Stevens Exploration Management Corp.

Logging Contractor: Geo-Recon International Ltd.

| Graphic | From | To | Description | % Recov. |
|---------|-------|-------|--|----------|
| | 0.0 | | OVERBURDEN: 0' to 31.5': Silt with 10% to 40% ice | Tricone |
| | 25' | 31.5' | | |
| | 31.5' | | COAL: 31.5' to 81.5': clay content varies from 10% to 40%; bright bands vary from 5% to 20%; coal highly fragmented; bedding angle to core - 50° | Cored |
| | 50' | | | |
| | 75' | 81.5' | bottom of Coal | |
| | 81.5' | 83' | CLAY: 81.5' to 83'; | |
| | 83' | | QUARTZITE: 83' to 98'; | Tricone |
| | 90' | 98' | T. D. 98' | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record HOLE NO. DH-12-82

Location: 19+37 N, 00 W, BL II Property: Chicago Creek
 Elevation: 192' From: 0' To: 30'
 Azimuth: Vertical Non-Core: 113' 123'
 Dip: 90° Cored: 30' 113'
 Length: 123' T. D. Non-core hole size: 4.5"
 Started: 9/1/82 Core size: HX (2.5")
 Completed: 9/2/82 Non-core bit type: Tricone
 Logged: Lithology Core bit type: surface set
 Logged by: Clyde Ringstad Core barrel type: Split tube
 Hole Probed: 9/3/82 Drill type: Longyear 38
 Logs Run: Gamma, Density Fluids used: Quik Gel
 Drilling Contractor: Denali Drilling Inc.
 Geological Contractor: Stevens Exploration Management Corp.
 Logging Contractor: Geo-Recon International Ltd.

| Graphic | From | To | Description | % Recov. |
|---------|------|-----|---|----------|
| | 0.0 | | OVERBURDEN: 0' to 28': Silt with 10% to 40% ice | Tricone |
| | 25' | 28' | CLAY: 28' to 123': grey to tan color; 1% to 5% coal fragments | Cored |
| | 28' | | | |
| | 50' | | | |
| | 75' | | | |
| | 90' | 94' | Clay has greenish cast | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record

HOLE NO. DH-12-82
PAGE NO. 2 of 2

| Graphic | From | To | Description | % Recov. |
|---------|------|------|----------------|----------|
| | 100' | | CLAY: as above | |
| | | | | Tricone |
| | 125' | 123' | T. D. 123' | |
| | | | | |
| | 150' | | | |
| | | | | |
| | 175' | | | |
| | | | | |
| | 200' | | | |
| | | | | |
| | 225' | | | |
| | | | | |
| | 250' | | | |
| | | | | |
| | 275' | | | |
| | | | | |
| | 300' | | | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record HOLE NO. DH-13-82

Location: 19+07 N, 30 E, BL II **Property:** Chicago Creek

Elevation: 189' **From:** **To:**

Azimuth: Vertical **Non-Core:** 0' 123'

Dip: 90° **Cored:** NONE

Length: 132' T.D. **Non-core hole size:** 4.5"

Started: 9/2/82 **Core size:**

Completed: 9/3/82 **Non-core bit type:** Tricone

Logged: Lithology **Core bit type:**

Logged by: Clyde Ringstad **Core barrel type:**

Hole Probed: 9/3/82 **Drill type:** Longyear 38

Logs Run: Gamma, Density **Fluids used:** Quik Gel

Drilling Contractor: Denali Drilling Inc.

Geological Contractor: Stevens Exploration Management Corp.

Logging Contractor: Geo-Recon International Ltd.

| Graphic | From | To | Description | % Recov. |
|---------|------|-----|--|----------|
| | 0.0 | 6' | OVERBURDEN: 0' to 6'; silt with ice | Tricone |
| | 6' | 20' | Sand, silt and clay with coal @ 10.5 to 11', 12.5 to 14.5', 16 to 20' | |
| | 25' | | Sand, silt and clay with interbedded thin coal seams @ 33.5' to 34.5', 66.5' to 68', | |
| | 50' | | | |
| | 75' | | | |
| | 90' | | | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record

HOLE NO. DH-13-82
PAGE NO. 2LB: of 2

| Graphic | From | To | Description | % Recov. |
|---------|------|------|---|----------|
| | 100' | 100' | bottom of sand, silt and clay Quartzite; T.D. 115' | Tricone |
| | | 115' | | |
| | 125' | | | |
| | 150' | | | |
| | 175' | | | |
| | 200' | | | |
| | 225' | | | |
| | 250' | | | |
| | 275' | | | |
| | 300' | | | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record HOLE NO. DH-14-82

Location: 19+37 N, 1+00 E, BL II **Property:** Chicago Creek

Elevation: 197" **From:** **To:**

Azimuth: Vertical **Non-Core:** 0 30'

Dip: 90° **Cored:** NONE

Length: 30' T. D. **Non-core hole size:** 4.5"

Started: 9/3/82 **Core size:**

Completed: 9/3/82 **Non-core bit type:** Tricone

Logged: Lithology **Core bit type:**

Logged by: Clyde Ringstad **Core barrel type:**

Hole Probed: **Drill type:** Longyear 38

Logs Run: **Fluids used:**

Drilling Contractor: Denali Drilling Inc.

Geological Contractor: Stevens Exploration Management Corp.

Logging Contractor:

| Graphic | From | To | Description | % Recov. |
|---------|------|-----|---|----------|
| | 0.0 | 30' | SILT: dark brown, frozen QUARTZITE at T. D. of 30' | Tricone |
| | | | | |
| | | | | |
| | 25' | | | |
| | | | | |
| | | | | |
| | 50' | | | |
| | | | | |
| | | | | |
| | 75' | | | |
| | | | | |
| | | | | |
| | 90' | | | |

APPENDIX B
REPORT OF GEOPHYSICAL STUDIES

REPORT OF GEOPHYSICAL STUDIES
NORTHWEST ALASKA COAL EXPLORATION
CHICAGO CREEK SITE

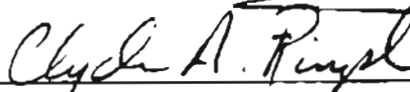
TO

DENALI DRILLING, INC.
6000 "A" STREET
ANCHORAGE, ALASKA 99503

BY

GEO-RECON INTERNATIONAL, LTD.
919 NORTHEAST 185TH
P.O. BOX 55189
SEATTLE, WASHINGTON 98155

DECEMBER 20, 1982



CLYDE A. RINGSTAD
GEOPHYSICIST

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| DISCUSSION OF ELECTROMAGNETIC STUDIES | 1 |
| DISCUSSION OF BOREHOLE LOGGING STUDIES | 2 |
| DISCUSSION OF THE INDIVIDUAL DRILLHOLES | 4 |
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| DH-7-82 | 5 |
| DH-8-82 | 5 |
| DH-9-82 | 5 |
| DH-10-82 | 6 |
| DH-11-82 | 6 |
| DH-12-82 | 7 |
| DH-13-82 | 7 |

INTRODUCTION

This report presents the results of geophysical studies accomplished for the Chicago Creek Coal Exploration Program near Kotzebue, Alaska. These studies consisted of geophysical borehole logging techniques and electromagnetic methods of resistivity mapping. The original geophysical program consisted of only the borehole logging, however, when we arrived on-site, your geologist requested us to perform the additional surface geophysical exploratory techniques. This additional geophysical exploration was performed to guide the drilling program when it became apparent that the strike of the coal beds deviated from previously published data.

DISCUSSION OF ELECTROMAGNETIC STUDIES

A total of 3,800 lineal feet of electromagnetic (EM) profiling was accomplished. The equipment used was a Geonics Limited, EM 34-3 Terrain Conductivity Meter. The EM 34-3 is a two-man portable unit consisting of a transmitter and receiver coil connected with a short length of multi-conductor wire. The intercoil spacing is measured electronically so that the receiver unit is utilized to set the coils at the correct spacing of 10, 20 or 40 meters. The effective depth of penetration varies directly with the intercoil spacing and frequency of the transmitted signal.

Shown below is the data for the coil configuration used on this project:

| <u>INTERCOIL SPACING</u> <u>in Feet</u> | <u>FREQUENCY</u> <u>in KHz.</u> | <u>EXPLORATION DEPTH</u> <u>in feet</u> |
|--|------------------------------------|--|
| 32.8 | 6.4 | 24.6 |
| 65.6 | 1.6 | 49.2 |
| 131.2 | 0.4 | 98.4 |

Locations of the EM profiles are shown on Figure 1, Exploration Plan, and the results of the EM studies are shown in Figures 2 and 3, Resistivity Cross-Sections.

The basis for using EM studies for coal exploration, at this site, is that the electrical resistivity of the coal strata should be sufficiently different than that of the surrounding rock. As shown on EM profiles 1, 2, 3 and 5, the electrical data indicates a slight to moderate increase in resistivity east of the previously established baseline. However, EM profile 4 appears to have a similar increase west of the baseline. Based upon the data in profiles 1, 2, 3 and 5, we recommended that drilling locations be shifted slightly to the north.

We also completed two EM profiles across DH-2-82 and DH-3-82. No significant resistivity variations were in either of these profiles.

DISCUSSION OF BOREHOLE LOGGING STUDIES

The Natural Gamma and Gamma-gamma Density logs were recorded in eight drillholes: DH-6-82, DH-7-82, DH-8-82, DH-9-82, DH-10-82, DH-11-82, DH-12-82 and DH-13-82. PVC plastic casing was installed in these holes before logging to prevent the holes from collapsing. The logging unit

used in the investigation was a Well Reconnaissance Model 10406. The radioactive source was 4 mcu of radium 226.

The Natural Gamma log records the natural radioactive decay of mineral isotopes (primarily potassium-40) contained in soil and rock. Clay and silt, generally having potassium rich minerals, usually exhibit higher radiation levels than do clean (quartz rich) sands and (calcium rich) limestones. Clean lignite coal has low gamma radiation except when there is a considerable clay contamination in the coal. The high clay content can mask the otherwise low radiation level of the coal. Coal can also on occasion act as a concentrator of radioactive salts in groundwater movement.

With the Model 10406, the Natural Gamma is recorded in counts per second with zero on the lefthand side of the chart and counts increasing to the right.

In the Gamma-gamma Density measurement, gamma rays are emitted continuously by a radioactive source a set distance from the detector crystal. The rays are subjected to collisions with atoms in the rock or soil formation and are deflected with each collision. When, and if, they lose sufficient energy, they are captured by an atom. The Gamma-gamma Density records the number of counts per second of the gamma ray back scatter from collisions within the subsurface material as recorded in the scintillation crystal. The lower the count rate (increasing counts to the right on the chart), the fewer the collisions, and therefore the lower the bulk density of the soil or rock. Lignite coal typically has a low density (low gamma counts) compared to sands and clays. This log can be adversely affected by washouts which show an apparent low density. The caliper log can aid in the interpretation of washout effect except where the log is run inside casing as in this instance.

The geologic cuttings logs were used to correlate and extrapolate characteristics between the subsurface materials and corresponding signature patterns on the geophysical logs. The Natural Gamma Log in most holes did not adequately identify coals (by low counts). The Gamma-gamma Density log generally did not exhibit a sufficiently strong low density contrast (low gamma counts) to separate it with confidence from similar readings in sands, gravels and even clays. The rather high clay content in most of the coal is probably the main factor which subdued the character of the Natural Gamma and Gamma-gamma Density logs. Nevertheless, certain distinct lithologic units can be identified and coal seams and partings measured when used in conjunction with the geologist's log. Drillhole 13-82 which was cored shows very good correlation between the core and geophysical log of fairly thin coal seams between 10 and 35 feet deep.

DISCUSSION OF INDIVIDUAL DRILLHOLES

The following discussion of the individual drillholes is primarily to define bed boundaries with only speculation as to the probable geologic material.

DH-6-82

The top of the coal sequence is not obvious on the geophysical logs. There are distinct geophysical breaks in the hole however. An abrupt Gamma-gamma Density change to a lower density clay occurs at 50 feet. This is a major shift in the density log from denser material above to less dense material below 50 feet. It is possible that factors unrelated to lithology are contributing to this shift, such as collapse

behind the casing. There is a clay (?) parting at 63 to 65 feet. There is a general lithology change from about 90 feet to a more clayey, high density material. The overall low reading on the Natural Gamma log of this hole is more characteristic of clean, uniform lignite. Drillhole 6-82 had the lowest counts per second Natural Gamma log of any of the holes in this study.

DH-7-82

There are several identifiable changes on the Gamma-gamma Density log. Lithologic description is from the geology log. The Natural Gamma log of this hole shows little character. From 15.5 to 40 feet there is a unit of silt with varying ice content. Between 22 and 27.5 feet there are a number of low density seams, ice lenses, or possible washouts. The coal seam on the geophysical log extends from 38.5 to 76.5 feet. There may be a clayey bed or denser coal at the base of the geophysical coal sequence from 76.5 to 79.5 feet. From 99 feet to TD of the geophysical log, there is a denser clay.

DH-8-82

The top of coal from the density log was recorded at 50.5 feet. There is a silt or clay seam within the surface ice unit at 27 to 29 feet. The silt layers within the coal were too thin to be identified on the geophysical logs. Sections of clay/silt concentration may be at 54-55, 61-62, 67-68, 69-70.5 and 73-74 feet.

DH-9-82

The geophysical logs show no evidence of coal in this hole. The Gamma-gamma Density log does show a lithologic

change from cleaner (sand?) near the surface to dirtier (clayey?) material deeper at 22 feet. The hole is collapsed behind the casing and blocked at 29 feet.

DH-10-82

Although there is apparently no coal in the hole, the geophysical logs can differentiate basically separate units above and within the bedrock. From 0 to 14 feet there is a low density, clean material; from 14 to 20.5 feet is silt or clay; 20.5 to 36 feet a unit which shows characteristics of a coal section or fairly clean sand, particularly between 29 and 36 feet; another denser section similar to coal between 45 and 71 feet with clayey partings; and a very uniform material from 71 feet to TD of the geophysical log. The character of apparent low density seams between 20.5 and 71 feet may be due to washouts of more highly fractured materials.

DH-11-82

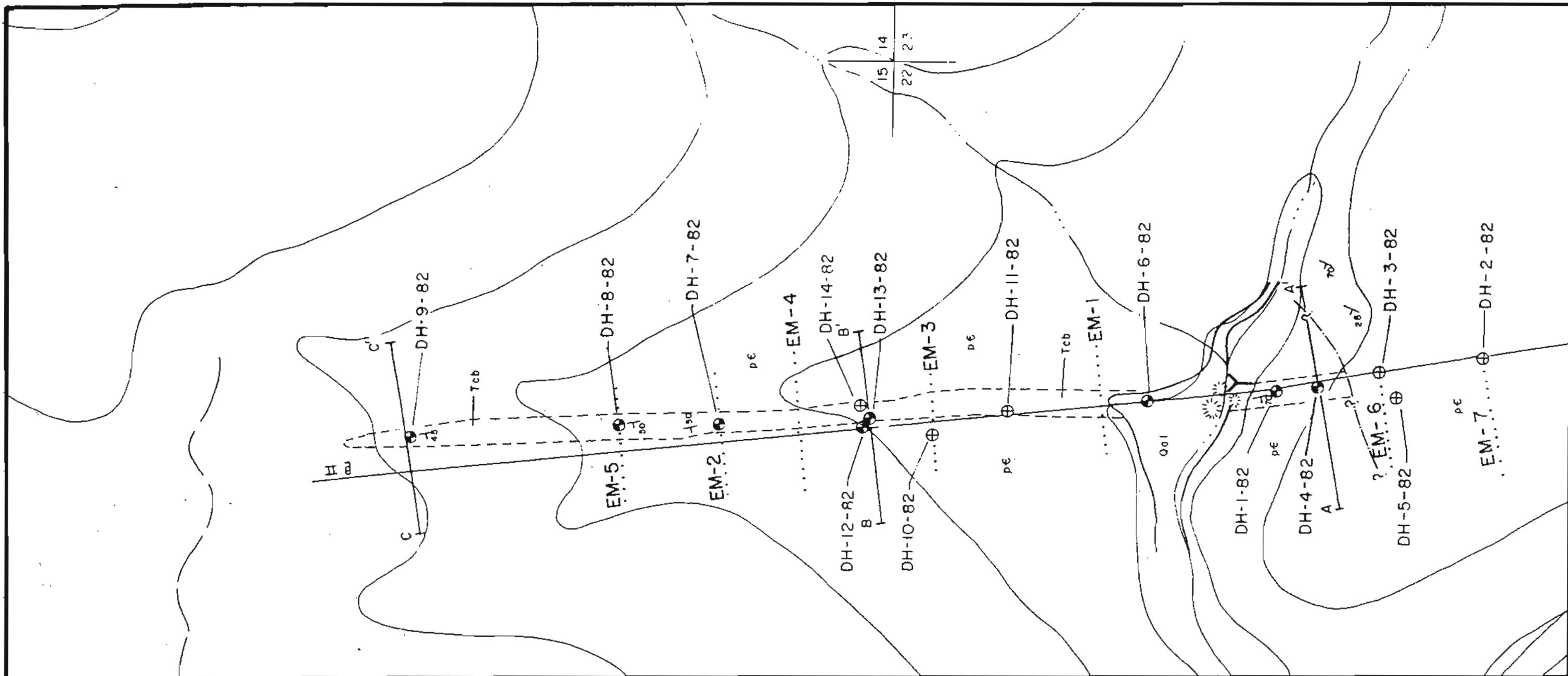
The section of coal from 26.5 to 50 feet exhibits a lower density with higher percentage of clay than does the lower coal section from 54 to 81 feet. This is the reverse of the effect that clay usually has on coal density. There is a clay parting from 23.5 to 24 feet and 25 to 26.5 feet; coal from 26.5 to 54 feet although it seems to be grading to carbonaceous clay from 50 to 54 feet; and a cleaner coal (from Natural Gamma log) from 54 to 73 feet. The coal may be becoming dirtier from 73 to TD of the geophysical log. The clay parting which begins to show at the bottom of the geophysical logs at about 80 feet may be a bottom hole effect of the cuttings settling out, hole size, etc.

DH-12-82

There is only a fair indication of coal from 26 to 30 feet with a possible 6-inch parting at 28 feet. There is no indication of this coal on the Gamma-gamma Density log. The coal is probably too dirty to show variation on the density log from the clay and silt boundary materials. There may be a change in the clay between 69 and 84 feet.

DH-13-82

The core log and the geophysical logs show very good correlation for coal seams and partings in the section from 10 to 35 feet. The Gamma-gamma Density log shows a basic change in lithology at about 33 feet to a higher density and a slight shift in the Natural Gamma to a dirtier material. The Natural Gamma log shows clay partings at 74 to 75.5 feet, 83 to 86 feet, and 87 to 88 feet. The Gamma-gamma Density log indicates that the deeper material is denser (sandier?) from about 76 feet to 98 feet although the Natural Gamma does not confirm the sand becoming appreciably cleaner.



LEGEND

- ELECTROMAGNETIC PROFILE
- EM-# ELECTROMAGNETIC PROFILE NUMBER

SCALE: 1" = 12,000



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 COAL EXPLORATION
 CHICAGO CREEK SITE
 GEOPHYSICAL EXPLORATION
 PLAN

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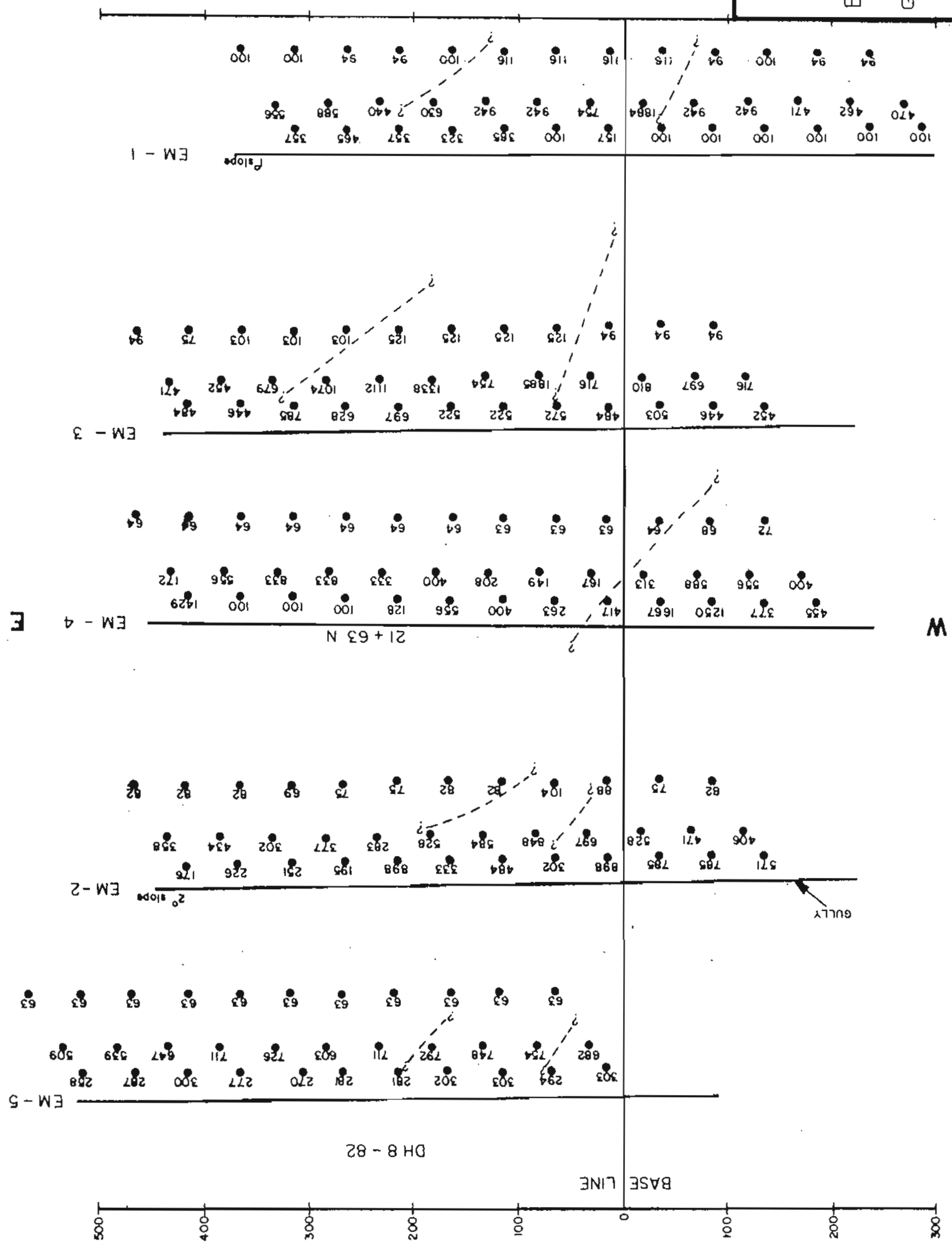
NORTHWEST ALASKA
 COAL EXPLORATION
 CHICAGO CREEK SITE
 ELECTROMAGNETIC PROFILE

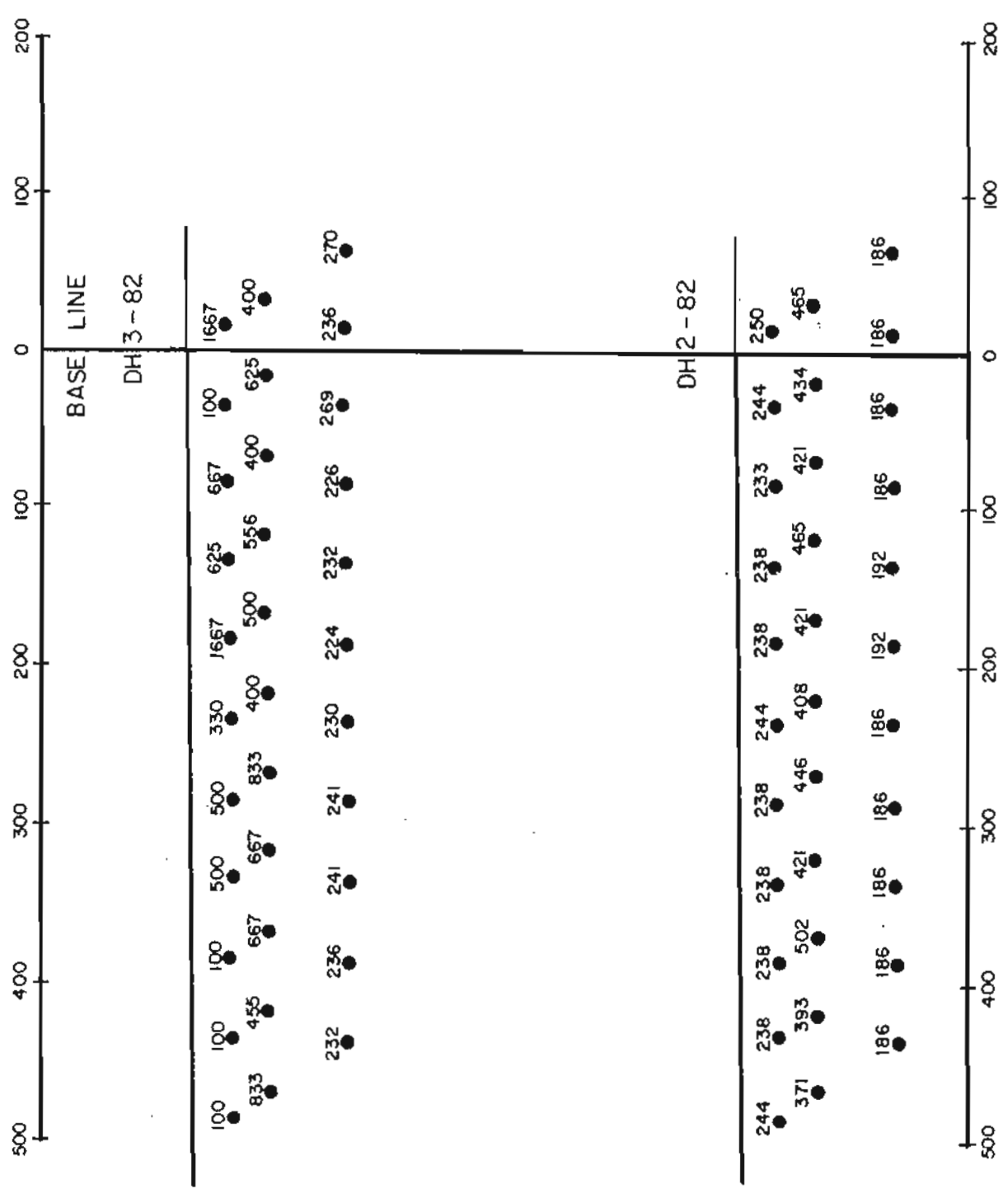
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FIG. 2

SCALE: 1" = 100'





E

W

SCALE: 1" = 100'

NORTHWEST ALASKA
 COAL EXPLORATION
 CHICAGO CREEK SITE
 ELECTROMAGNETIC PROFILE

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FIG. 3

APPENDIX C
CHICAGO CREEK BIBLIOGRAPHY

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APPENDIX D
KOYUK DRILL LOGS

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record HOLE NO. TH-8

| | |
|---------------------------------|--|
| Location: See Figure 5 | Property: Koyuk |
| Elevation: 8.2' ASL | From: To: |
| Azimuth: N/A | Non-Core: 0' 21.0' |
| Dip: 90° | Cored: None |
| Length: 21.0' | Non-core hole size: 3.0" |
| Started: 10/11/82 | Core size: N/A |
| Completed: 10/11/82 | Non-core bit type: Auger "fish-tail" |
| Logged: Lithology | Core bit type: N/A |
| Logged by: K. H. Manning | Core barrel type: N/A |
| Hole Probed: N/A | Drill type: Minute Man |
| Logs Run: N/A | Fluids used: N/A |

Drilling Contractor: Denali Drilling Inc.

Geological Contractor: Stevens Exploration Management Corp.

Logging Contractor: N/A

| Graphic | From | To | Description | % Recov. |
|---------|------|------|---|--------------|
| | 0 | 1.0 | SAND: with some gravel and silt | N/A |
| | 1.0 | 6.5 | SILT: with some sand | (Auger Spin) |
| | 6.5 | 10.0 | SILT: with some clay | |
| | 10.0 | 13.5 | SILT: with some coal fragments, possibly 1"-8" layer of coal @10' and some clay | |
| | 13.5 | | COAL: 1" to 2" layer | |
| | 13.5 | 14.0 | SILT: with some coal fragments and some clay | |
| | 14.0 | 15.0 | SILT: carbonaceous with some clay & some coal fragments, organic rich | |
| | 15.0 | 16.0 | COAL: @ 15.0', 6" to 1' thick | |
| | 16.0 | 17.5 | SILT: carbonaceous with some clay | |
| | 17.5 | 18.0 | SILT: with some clay | |
| | 18.0 | 21.0 | SILT: organic rich with some clay, some sub-bituminous coal | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record

HOLE NO. TH-8
PAGE NO. 2 of 2

| Graphic | From | To | Description | % Recov. |
|---------|------|----|---|----------|
| | 100' | | fragments, and some bi-valve shells CLAY: with some silt and some coal fragments T.D. 21.0' | |
| | 125' | | | |
| | 150' | | | |
| | 175' | | | |
| | 200' | | | |
| | 225' | | | |
| | 250' | | | |
| | 275' | | | |
| | 300' | | | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record HOLE NO. TH-12

| | |
|---------------------------------|---|
| Location: See Figure 5 | Property: Koyuk |
| Elevation: 8.2' ASL | From: To: |
| Azimuth: N/A | Non-Core: 0.0 24.0 |
| Dip: 90° | Cored: None |
| Length: 24.0 | Non-core hole size: 3.0" |
| Started: 10/12/82 | Core size: N/A |
| Completed: 10/12/82 | Non-core bit type: Auger "fish-tail" |
| Logged: Lithology | Core bit type: N/A |
| Logged by: K. H. Manning | Core barrel type: N/A |
| Hole Probed: N/A | Drill type: Minute Man |
| Logs Run: N/A | Fluids used: N/A |

Drilling Contractor: Denali Drilling Inc.

Geological Contractor: Stevens Exploration Management Corp.

Logging Contractor: N/A

| Graphic | From | To | Description | % Recov. |
|----------------|-------------|-----------|--|-----------------|
| | 0 | 1.5 | SILT: with some sand and gravel | N/A |
| | 1.5 | 7.0 | SILT: with some clay | (Auger Spin) |
| | 7.0 | 8.5 | SILT: carbonaceous with some clay, bivalve shells and coal fragments | |
| | 8.5 | 11.0 | SILT: with some clay and bivalve shells | |
| | 11.0 | 14.5 | SILT: with some clay, coal fragments and bivalve shells | |
| | 14.5 | 16.5 | COAL: 6"-10" thick seam | |
| | 16.5 | 19.5 | CLAY: with some silt and coal fragments | |
| | 19.5 | 20.5 | COAL: 4"-5" thick seam | |
| | 20.5 | 21.0 | COAL: 6"-8" thick seam | |
| | 21.0 | 22.0 | CLAY: with some silt | |
| | 22.0 | 22.4 | CLAY: with some silt; occasional 2"-3" sand layer | |
| | | | T.D. 24.0' | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record HOLE NO. TH-15

| | |
|---------------------------------|---|
| Location: See Figure 5 | Property: Koyuk |
| Elevation: 3.6' ASL | From: To: |
| Azimuth: N/A | Non-Core: 0.0' 18.0' |
| Dip: 90° | Cored: None |
| Length: 18.0' | Non-core hole size: 3.0" |
| Started: 10/12/82 | Core size: N/A |
| Completed: 10/12/82 | Non-core bit type: Auger "fish-tail" |
| Logged: Lithology | Core bit type: N/A |
| Logged by: K. H. Manning | Core barrel type: N/A |
| Hole Probed: N/A | Drill type: Minute Man |
| Logs Run: N/A | Fluids used: N/A |

Drilling Contractor: Denali Drilling Inc.

Geological Contractor: Stevens Exploration Management Corp.

Logging Contractor: N/A

| Graphic | From | To | Description | % Recov. |
|---------|------|------|---|----------|
| | 0 | 1.5 | SAND: with some gravel | N/A |
| | 1.5 | 7.0 | SILT: with some sand | |
| | 7.0 | 8.0 | SILT: with some clay | |
| | 8.0 | 8.5 | COAL: 3"-4" thick seam | |
| | 8.5 | 9.0 | SILT: with clay and some coal fragments | |
| | 9.0 | 10.0 | COAL: seam | |
| | 10.0 | 12.5 | CLAY: with some silt and coal fragments | |
| | 12.5 | 15.0 | CLAY: with some silt | |
| | 15.0 | 18.0 | CLAY: light gray | |
| | | | T.D. 18.0' | |
| | | | | |
| | | | | |
| | | | | |

STEVENS EXPLORATION MANAGEMENT CORP.

Coal Logging Record HOLE NO. TH-17

| | |
|---------------------------------|---|
| Location: See Figure 5 | Property: Koyuk |
| Elevation: 8.1' ASL | From: To: |
| Azimuth: N/A | Non-Core: 0.0' 31.0' |
| Dip: 90° | Cored: None |
| Length: | Non-core hole size: 3.0" |
| Started: 10/12/82 | Core size: N/A |
| Completed: | Non-core bit type: Auger "fish-tail" |
| Logged: Lithology | Core bit type: N/A |
| Logged by: K. H. Manning | Core barrel type: N/A |
| Hole Probed: N/A | Drill type: Minute Man |
| Logs Run: N/A | Fluids used: N/A |

Drilling Contractor: Denali Drilling Inc.

Geological Contractor: Stevens Exploration Management Corp.

Logging Contractor: N/A

| Graphic | From | To | Description | % Recov. |
|---------|------|------|--|----------|
| | 0 | 2.0 | SAND: with some gravel | N/A |
| | 2.0 | 4.0 | SILT: with some clay | (Auger |
| | 4.0 | 8.0 | SILT: with some clay & bivalves | Spin) |
| | 8.0 | 10.0 | COAL | |
| | 10.0 | 11.0 | CLAY: with some silt | |
| | 11.0 | 12.5 | COAL | |
| | 13.0 | 16.5 | COAL: with occasional 1"-3" clay | |
| | 16.5 | 18.5 | CLAY: with some silt | |
| | 18.5 | 21.5 | COAL | |
| | 21.5 | 24.5 | COAL: with occasional 1"Ø3 clay | |
| | 24.5 | 25.5 | CLAY | |
| | 25.5 | 30.0 | *COAL: with occasional 1"-2" clay | |
| | 30.0 | 31.0 | CLAY | |
| | | | T.D. 31.0' | |
| | | | *No auger cuttings returned; based on drillers say-so. Auger flites coated with clay when augers pulled. | |

APPENDIX E
NORTON SOUND AREA COAL BIBLIOGRAPHY

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Figure 6 Drilling at Koyuk



Figure 7 Drilling at Koyuk