ALASKA DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

WAINWRIGHT

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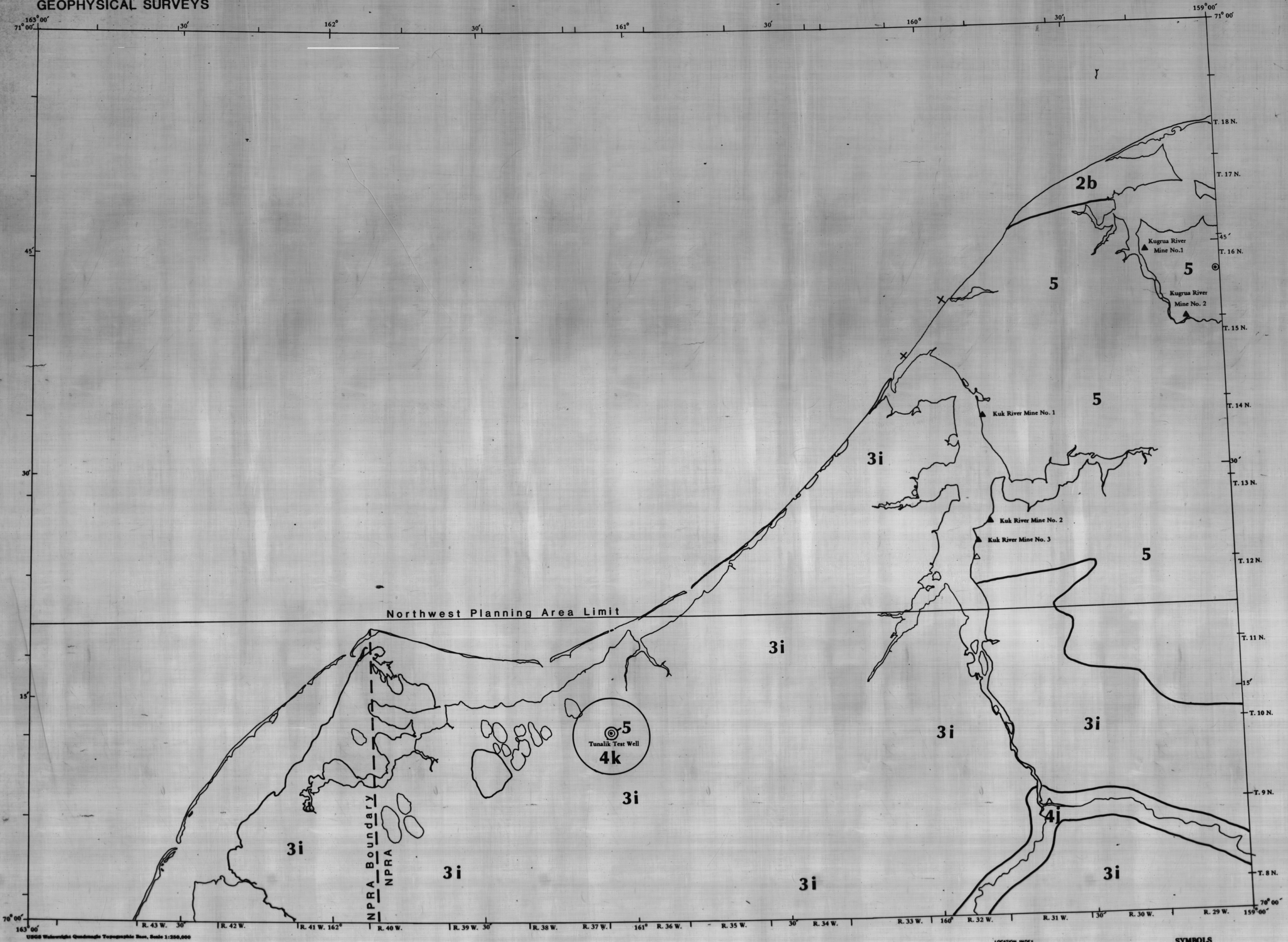
K. M. GOFF, J. CLOUGH , L. LUECK AND M. BELOWICH



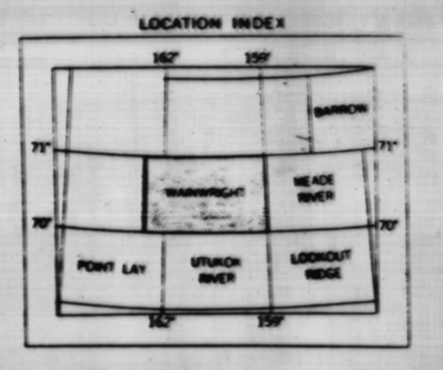
USGS Wainwright Quadrangle Topographic Base, Scale 1:250,000

SCALE 1:250,000

5 0 5 10 15 20 25 MILES

5 0 5 10 15 20 25 KILOMETERS

Alaska Department of NATURAL RESOURCES



SYMBOLS

- ▲ FORMER COAL MINE
- △ COAL OUTCROP OR PROSPECT
- × COAL FLOAT (GENERAL LOCATION)
- ◉ DRILLING DONE IN THIS AREA

COAL RESOURCE POTENTIAL OF THE WAINWRIGHT QUADRANGLE, ALASKA 1985

EXPLANATION

COAL RESOURCE RATING CRITERIA

The following resource rating criteria are organized on scale of 1 = low to 5 = high potential. A rating of 1 indicates virtually no possibility for substantial coal discoveries, and no known coal in the area. Categories 2 and 3 are for possible but unverified occurrences of coal. A 5 is the highest possible rating under this system. The letters 'a' through 'm' that may accompany the numbers 2 through 4 are meant to clarify and justify the number ratings assigned. In some cases, more than one letter is used, as in '2b,e'. These letters are only explanatory, like footnotes, and do not weight the ratings.

The areas outlined in heavy black on the map have been calculated according to the U.S. Geological Survey resource classification system (U.S.G.S. Circular 891), using available surface and subsurface data. The blocks use reliability of data available to determine how the resource potential is calculated (see 'coal reserves', Glossary).

1 Very low to low possibility for substantial coal discoveries; sedimentary and other rock units not known to host coal; these "barren" units vary from map to map; this rating based almost entirely on published general, broad-brush geological maps.

2 Low to medium possibility for substantial coal discoveries; these ratings based mostly on published general, broad-brush geology:

- □ **a** units with very minor coal shows elsewhere; possibly favorable rocks but no coal known at location;
- □ **b** queried rock unit or undifferentiated group (two or more rock units mapped together, so presence of coal-bearing unit is uncertain);
- □ **c** cover of recent (Quaternary) unconsolidated sediments suspected of being underlain by a formation that hosts coal elsewhere;
- △ **d** Tertiary basin; most of the coal on the Seward Peninsula is lignite (lower quality coal) found within Tertiary-aged sedimentary rocks confined in areas called basins (see 'basin,' Glossary); therefore, all such basins on the Peninsula potentially contain coal deposits;
- □ **e** unverified report of coal occurrence; off-hand reference to coal in published geological report; other second-hand or unconfirmed reports.

3 Medium to high possibility for substantial coal discoveries:

- □ **f** coal bearing formation close to exposed coal, e.g. other end of basin or syncline (see 2d, above, and Glossary) from known coal deposits;
- △ **g** scattered, small surficial coal shows or float (see Glossary) that may be weathering out of a hidden coal deposit;
- △ **h** "mined out" or formerly subeconomic sites where future investigation may reveal usable coal resources;
- □ **i** Cretaceous basin (see 2d, above, and Glossary): composed of Cretaceous-aged rocks known elsewhere to contain medium to large tonnages of good quality (subbituminous to bituminous) coal; rated higher than 2d both because of likely higher coal quality and because of high tonnage potential demonstrated, for example, by the large Cretaceous-aged Cape Beaufort coal field.

4 Known coal, lesser occurrences, and/or less well studied than 5's:

- ○ **j** marginal because of low rank (low Btu), low tonnage, structural complexity, or thin beds (even if coal is good quality and present in large amounts, thin beds may mean too much admixed waste).
- ○ **k** indicated and inferred resources (see Glossary) of 5's in favorable geology.
- △ **m** may include cases where drilling has disclosed some coal but where its extent is still unknown.

5 Known coal, medium to large measured resources (see Glossary) of usable quality coal. There is a large size difference between the smallest and largest but even the smallest is known to contain reserves that might be mineable under the right conditions. For example, the Chicago Creek coal deposit, on the Seward Peninsula, contains only one known thick bed of coal and is confined to a topographic basin (see Glossary); estimated tonnage for this deposit is a fraction of those calculated for the Deadfall syncline; and the Chicago Creek coal is lignite, while the Deadfall syncline coal is of higher, bituminous rank. Nevertheless, Chicago Creek rates a 5 as easily as the Deadfall syncline, for it contains potentially marketable coal, in adequate tonnage, close to tidewater.

Data Confidence

Each number rating, 1 through 5, has typical levels of data confidence. A rating of 1 often implies limited geological data as well as a lack of coal potential. A rating of 3 usually implies more and better data, or greater coal potential. It is, however, possible to have a rating of 3, signifying low to moderate coal potential, based upon a high level of data. This is the case in parts of the Point Lay Quadrangle for example, where a detailed geological mapping has shown that coal-bearing rocks are not coal-bearing. Conversely, it is also possible to have a high rating of 4 for which the data base is limited, but for which geologic conditions are highly favorable for significant coal resource potential, as in "4m". As a very general indication of the amount and depth of information upon which ratings are based, each rating above has been assigned one of the following confidence symbols:

○ Good data base △ Medium data base □ Poor or very general data base

These symbols are not meant as comments on the quality of work done by previous investigators, which in most cases is difficult to judge without rechecking the geology on the ground.

SUMMARY: WAINWRIGHT QUADRANGLE

The coal-bearing rock unit in the Wainwright Quadrangle is called the Corwin Formation. Outcrops of this unit are generally restricted to exposures along the Kuk and Kugrua Rivers and along the beaches around Wainwright and Peard Bay within the National Petroleum Reserve, Alaska.

The Cretaceous Corwin Formation is a clastic sedimentary assemblage of interbedded claystone, siltstone, sandstone, ironstone, conglomerate, coal, and minor bentonite. The formation is 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, 1967). The Corwin Formation underlies most of the north slope beneath Pleistocene and younger surficial deposits. Data from seismic work and three deep exploratory wells suggests that the unit is roughly divided into three zones (Callahan and Martin, 1980). Lower zone coal is generally thin and laterally continuous up to 12 miles. 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 feet thick and laterally persistent for as much as 6 miles. Beds in the northern part of the quadrangle tend to be thin and laterally continuous, while beds to the south are thicker but more discontinuous (Callahan and Martin, 1980).

Coal along the coast at Wainwright Inlet and on the banks of the Kuk River was first reporteded in 1889 by H.D. Woolfe, who described it as cleaner and of better quality than Cape Lisburne coal (Schrader, 1904; Collier, 1906). In 1901, F.C. Schrader of the U.S. Geological Survey (USGS) studied and sampled coal at several localities in the Wainwright Inlet area. Easily accessible beds have since been mined by primitive methods to supplement local fuel needs (Smith and Mertie, 1930).

Three mines on Kuk Lagoon southeast of Wainwright operated from the turn of the century, with most production in the 1930's (Lounsbury, 1974). The best known outcrops of Cretaceous coal-bearing strata in the Wainwright Quadrangle occur along the Kuk and Kugrua Rivers in the vicinity of these mines. Coal in the shaft of the mine closest to the village of Wainwright (Kuk River #1) could not be measured because it was flooded but the surrounding strata strike S. 3° E. and dip 7° W. The coal bed that was mined here is known to extend 1,000 feet along the shoreline (Toenges and Jolley, 1947). The Kuk River #2 mine has three separate beds 2.2 to 5.0 feet thick that strike S. 28° W. and dip 5° E. Two beds 5.2 feet and 3.8 feet thick at the Kuk River #3 mine strike S. 40° E. and dip 5° W. These three mines have produced a few hundred tons of coal for local use (Plangraphics, 1983). One mile past the Kuk River #3 mine, two coal beds 5.5 and 6 feet thick are probably extensions of the ones at the mine and continue for at least a mile along strike away from the mine (Lounsbury, 1974).

Acute fuel shortages in Barrow during World War II spurred interest in north slope coal deposits. In 1943-44 and in 1946, U.S. Bureau of Mines (USBM) geologists measured and sampled deposits at Peard Bay and on the Kuk River (Sanford and Pierce, 1946; Toenges and Jolley, 1947). In 1951, the U.S. Navy, as part of a petroleum exploration program in the Naval Petroleum Reserve (now called National Petroleum Reserve, Alaska), drilled a 7,000-foot test well near the Kaolak River, five miles south of the Wainwright Quadrangle. Though dry, the Kaolak test hole intersected 4,000 feet of coal-bearing Corwin Formation containing 36 coal beds between 3 and 26 feet thick (Collins, 1958). In the 1970's, two additional test wells, one near Peard Bay and the other near the Tunalik River, penetrated at least 2,600 feet of coal-bearing strata (Rao and Smith, 1983). These test wells and numerous closely spaced seismic measurements by the USGS and private industry have demonstrated that fairly continuous coal beds occur widely throughout the subsurface of the Wainwright Quadrangle (Callahan and Martin, 1980).

Two other abandoned mines occur along the east bank of the Kugrua River south of Peard Bay. Coal beds between 5 and 6 feet thick at the Kugrua River #1 mine have been sampled from prospect pits by the USBM, as has a 6-foot bed at the Kugrua River #2 mine (Sanford and Pierce, 1946). Other minor occurrences in the Wainwright Quadrangle include coal float on the beach near the village of Wainwright. This coal may be derived from erodeding offshore beds, or may be brought from outcrops elsewhere on the coast by longshore sediment transport. Thin coal beds on the Kaolak River and considerable amounts of coal float on river bars suggest that other beds may be concealed nearby under surficial material (Smith and Mertie, 1930). Several beds up to 3 feet thick are poorly exposed on the Avalik River a short distance above a place the natives call Kangik. Coal beds are recognized at a number of other places on the Anvalik but most are less than one foot thick (Smith and Mertie, 1930).

Analyses of coal from outcrops in the Wainwright Quadrangle yield moderate moisture, low ash and sulfur, and an apparent rank from lignite to subbituminous A, with subbituminous B most abundant (Callahan and Martin, 1980). Subsurface coals increase in rank from subbituminous B near the surface to subbituminous A at depth. Heating values for these coals (as received) average 9,500 Btu/lb.

Although geological evidence suggests that coal beds in the Wainwright Quadrangle are fairly continuous, no reserve estimates are available for this quadrangle. Significant coal resources discovered anywhere near the Kuk and Kugrua Rivers could be developed as a local source of fuel for the settlements of Wainwright and Barrow.

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Coal Rank - Based on Moist, Mineral Matter Free Btu/lb

Lignite: 6,000 to 8,300 Btu/lb.

Subbituminous: subbituminous-C = 8,300 to 9,500 Btu/lb.
subbituminous-B = 9,500 to 11,00 Btu/lb.

Bituminous: subbituminous-A to high volatile bituminous-C = 11,000 to 13,000 Btu/lb.
high volatile-B bituminous = 13,000 to 14,000 Btu/lb.
high volatile-A bituminous = 14,000 to 16,000 Btu/lb.

Coal Rank - Based on Dry, Mineral Matter Free Fixed Carbon %

	BTU/Lb	Fixed Carbon %
Bituminous (medium volatile)	11,000 to 16,000 Btu/lb	69-78%
Bituminous (low volatile)	16,000+ Btu/lb	78-86%
Semi-anthracite	"	86-92%
Anthracite	"	92-98%

Some Equivalents

1 Btu (British thermal unit) equals 250 calories of heat. There are approximately 138,000 Btu to 1 gallon of fuel oil or diesel. 1 Kwh (kilowatt hours) equals approximately 3,400 Btu.

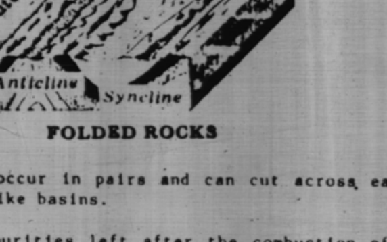
Therefore, using an average value of 12,000 Btu/lb for calculation:

1 ton of coal = 144 gallons of fuel for electric power
1 ton of coal = 176 gallons of fuel for home heating

Since the Btu value of coal varies considerably, 1 ton of a lower ranked coal, such as a lignite averaging 6,000 Btu/lb, is the equivalent of half as many gallons of fuel as a coal with an average of 12,000 Btu/lb. Conversely, 1 ton of 12,000 Btu/lb coal equals 176 gallons of fuel oil, but it would take 2 tons of 6,000 Btu/lb coal, or twice as much, to generate the same amount of heat.

GLOSSARY

anticline/syncline ----- Rock structures formed from the large-scale folding of massive rock units; the upward folded portion of the rock is the anticline, with an inverted U-shaped cross section; the downward folded part is the syncline, with a U-shaped cross section:



FOLDED ROCKS

do not necessarily occur in pairs and can cut across each other forming more complex structures like basins.

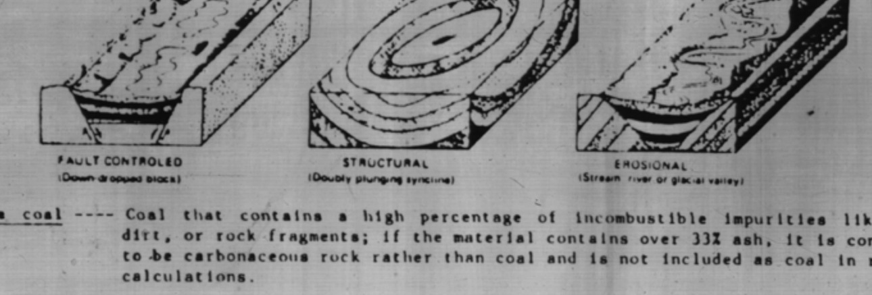
ash ---------- Residual mineral impurities left after the combustion of coal. High-ash coal has more than 15% total ash; coal with less than 8% total ash is low-ash coal.

ASTM --------- American Society for Testing Materials; sets many specifications for materials and standards for materials testing used in the United States.

basin -------- 1) Structural: a syncline that dips inward in all directions (see 'syncline'); usually formed by the oblique intersection of two synclines, or by downfaulting of underlying rock strata; the relationship of a structural basin to present topography is largely coincidental; for example, rocks (and coal) of the Cretaceous structural basins of the Point Lay Quadrangle probably formed in a relatively flat environment, were buried by continued sedimentation, and were later folded in two cross-cutting directions to form structural basins; present topography of these basins is a product of differential weathering of the various rock types of which they are composed.

2) Topographic: sediments (and vegetable matter) deposited in an existing valley or basin, where they are compacted into rock (and coal) by subsequent burial; for example, rocks of the Tertiary basins of the Bendeleben Quadrangle are much younger than the rocks forming the old valleys they now occupy; such valleys or basins may be relatively undeformed.

SOME TYPES OF BASINS



bone coal ---- Coal that contains a high percentage of incombustible impurities like clay, dirt, or rock fragments; if the material contains over 33% ash, it is considered to be carbonaceous rock rather than coal and is not included as coal in resource calculations.

Btu ---------- British thermal unit; one Btu equals the amount of heat needed to raise the temperature of one pound of water one degree fahrenheit; the standard unit used in the United States to describe the heating value of fuels (most other countries use kilocalories per kilogram as a standard thermal unit).

coal --------- A compact, light-weight, dark-brown to glossy-black rock composed of vegetable material that has been physically and chemically altered to a concentrated combustible product.

coal float --- Fragments of coal displaced from the parent coal bed by erosion; found in stream gravel, in talus (gravity-transported rock debris) at the bases of bluffs, in landslide material, and elsewhere downslope of a coal outcrop.

coal reserves ----- Identified, recoverable coal resources:

1. measured - identified undeveloped coal reserves with the highest degree of geological assurance; calculated by extrapolating ¼ mile beyond coal outcrops and drill-hole intercepts; by convention includes only coal beds at least 14" thick.

2. indicated - undeveloped coal reserves with a moderate degree of geological assurance; calculated by extrapolating coal outcrop and drill-hole data to a depth of 1000' and for a horizontal distance of ¼ to 1 mile.

3. inferred - undeveloped coal reserves with the lowest degree of geological assurance; calculated by extrapolating coal outcrops and drill-hole data to a depth of 1,000' and a horizontal distance of 1 to 3 miles.

coal resource ----- Natural deposit of coal in the earth's crust, occurring in a form and amount such that economic extraction is currently or potentially feasible; includes both reserves and presently non-economic deposits most likely to become mineable in the future.

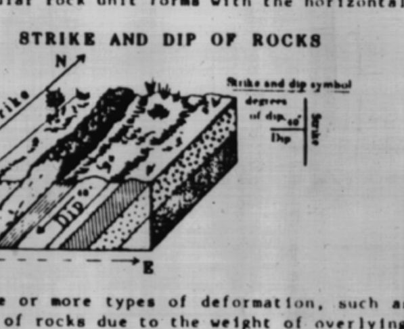
coal rubble ------- Similar to coal float, but often the fragments of a fractured sub-surface coal bed frost-jacked to the surface through freeze-thaw action, or the fractured and fragmented coal particles that accumulate from the weathering of a surface or near-surface coal occurrence; found close to the parent coal bed.

coking coal --------- A form of coal, usually of bituminous rank, that softens and flows when heated to just below the point of ignition; during this process, volatile compounds escape as gasses, leaving a dull-gray, porous mass called coke.

deformation -- Any physical change in the attitude, shape, or volume of rocks from the configuration they had when formed; folding, tilting, and warping are forms of deformation, as are compression (squeezing) and tension (stretching).

dip ---------- The angle a tabular rock unit forms with the horizontal:

STRIKE AND DIP OF ROCKS



results from one or more types of deformation, such as uplift, fault movement, or down-warping of rocks due to the weight of overlying sediments.

fixed carbon - The solid residue, other than ash, obtained by destructive distillation of coal; determined by definite prescribed ASTM methods.

strike ------- The line formed by the intersection of the dip plane of a tabular rock unit with the horizontal; for example, if the dip is some angle toward the west, then the the strike is north-south (see 'dip').

stripping ratio -------- The ratio of overburden (soil and rock covering the coal) to coal being mined by strip mining methods; reserve estimates usually omit coal deposits with stripping ratios higher than about 10:1 because these are seldom economic.

volatile matter ------- In coal, those products, exclusive of moisture, given off as gas and vapor, determined by definite prescribed ASTM methods.

Mississippian --- The older ½ of the geologic period called the Carboniferous, during which many of the world's coal deposits formed; the Mississippian subdivision spans the time from 360 million to 320 million years ago; in this report, occurs only in the summary for the Point Hope Quadrangle.

Cretaceous ------ Geologic period spanning the time from 140 million to 65 million years ago; many of Alaska's coals were formed during the Cretaceous period.

Tertiary -------- Geologic period spanning the time from 65 million to 1.5 million years ago; many of Alaska's coals are Tertiary in age.

Quaternary ------ Geologic period spanning the time from the end of the Tertiary through the present, or the last 1.5 million years.

Types of Coal

The many types of coal in Alaska are classified, or ranked, according to physical and chemical properties. A coal's rank is determined by laboratory testing of its properties using ASTM standardized methods. Rank is based primarily on heating value (Btu/lb.) and content of certain physical components. The main coal rank classifications are: A) lignite - very low rank; B) subbituminous - low to medium rank; C) bituminous - medium to high rank; and D) semi-anthracite and anthracite - very high rank. Each of these rank classifications has discrete subdivisions (see below), and distinct properties that help to determine its optimum potential use. The uses that are appropriate for one type of coal may not be appropriate for another type.

Classification and use are determined by a coal's rank, its heating capacity, and its weathering characteristics (whether it remains compact or readily crumbles and decomposes under surface conditions). Lignites and subbituminous coals are often satisfactory for local use, such as home heating and power generation, but poor weathering behavior and low heating values typically make the long distance transportation and storage of low-rank coal impractical. Bituminous coals are of higher rank than lignites and subbituminous coals, and may be coking, caking or non-coking. Coking and caking coals soften and flow prior to ignition. The escape of volatile components, under heat in the absence of oxygen, results in a dull-grey, porous mass called "coke." This material, which has a high percentage of fixed carbon, is used in the production of steel. Caking and non-coking bituminous coals are not suitable for metalurgical use, but have high heating values, and do not weather as badly as lower rank coals. Long distance transportation and storage of these coals may therefore be feasible. Anthracite, the highest rank of coal, has the highest heating value per pound, with the fewest residual impurities, but there is very little anthracite coal in Alaska. At a very high fixed-carbon content, anthracite becomes graphite, which cannot be used for fuel.