Public-data File 86-90

ALASKA: COAL FIELDS AND SEAMS - 1987

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November 1986

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ALASKA: COAL FIELDS AND SEAMS*
for 1987 Keystone Coal Industry Manual

INTRODUCTION

Coal is widely distributed in Alaska. It is known to occur in more than half of the state's 153-1:250,000 scale quadrangle map areas (Figure 1), and geologic formations containing coal underlie more than 9 percent of Alaska's land area. Alaska's total hypothetical resources of coal are estimated to exceed 5.6 trillion short tons (Table 1) or more than the total United States identified resources in 1972 (Averitt, 1973). Alaska is believed to hold about half of the United States' estimated 30 percent share of world coal resources (Figure 2). Alaska's coal is dominantly bituminous of Cretaceous age or subbituminous of Cretaceous and Tertiary age. The most accessible major resource is the subbituminous Tertiary aged coal of the Nenana and Cook Inlet-Susitna provinces (Figure 3).

Figures 1-3, Table 1---NEAR HERE

Coal was discovered in Alaska by foreign explorers in 1786; the first documented production was in 1855. Small-scale mining has been recorded at numerous sites throughout the state since that time. Local mines were developed to fuel river steamboats, placer gold mines and canneries before 1900, but significant production began in 1917 after completion of the Alaska Railroad into the Matanuska field; for the first time, over a quarter-million tons of coal were produced.

During the era beginning with World War I and extending up to the present time, coal has been mined mainly in the Healy Creek

*Prepared by R.D. Merritt, Alaska Division of Mining and Geological and Geophysical Surveys, Fairbanks, Alaska, January, 1987.

and Hosanna Creek (production over 20 million short tons) and Matanuska (production over 7 million short tons) coal fields. Pre-World War II coal production in Alaska was dominated by underground mining. A period of combined underground and surface mining followed from around 1943 until the early 1960's. Recent production has been entirely by surface mining. Annual coal production first peaked in 1966 at over 927,000 short tons. A new maximum production of about 1.4 million short tons was attained in 1985, as export shipments to Korea augmented domestic production for the Fairbanks area. Production in 1986 was about 1.5 million short tons.

RESOURCES

Within the vast hypothetical resource base (which includes unspecified bodies of coal resources in beds that may reasonably be expected to exist in known mining districts under known geologic conditions; Brobst and Pratt, 1973), more than 170 billion short tons of identified resources (Table 1) of bituminous and subbituminous coal, established by location, rank, and information on quality and quantity, exists in the Northern Alaska, Nenana, and Cook Inlet-Susitna provinces. Significant identified resources are present in other coal fields within the Alaska Peninsula, Gulf of Alaska, Seward Peninsula, Yukon-Koyukuk, and Upper Yukon provinces. Further, although the main coal provinces are known and most coal fields identified, the extensive amount of cover and the fact that significant amounts of coal can occur in isolated basins, is consistent with exploration identification of other resources and reserves.

AGE AND DISTRIBUTION

Except for Mississippian coal of the Northern Alaska province, Alaska coal resources formed in widespread deltaic and continental depositional sustems of Cretaceous and Tertiary time. Especially in the coal of Tertiary age, fault systems with complex gravity and strike-slip motions controlled basin formation and influenced depositional areas by differential settling.

Minor coal occurrences are distributed from southeast Alaska to the Alaska Peninsula and interior parts of the state. The major provinces are Northern Alaska, Nenana, and Cook Inlet-Susitna. Because of tidewater location or proximity to the Alaska Railroad, the Nenana and Cook Inlet-Susitna provinces have competitive advantages related to marine transport distances (Figure 4). However, the undeveloped Alaska Peninsula, Bering River, and westernmost northern Alaska fields also are essentially at tidewater and deserve further evaluation both for export and for coastal shipping within the Alaska domestic market.

Figure 4---NEAR HERE

QUANTITY AND QUALITY

The identified coal resource base of Alaska is sufficient for both domestic and export use for at least the next century and probably for 2-3 centuries based on current rates of consumption. In summary form, the identified resources arranged by province, with general notation of rank, are listed in Table 2.

Table 2---NEAR HERE

With a few exceptions of coal with average sulfur content to about 1 to 2 percent, most Alaska coal, and all that considered for export is low sulfur, in many cases containing less than 0.5 percent. These potential export coals also have favorable low metallic trace elements, good ash-fusion characteristics, and low nitrogen contents.

ECONOMICS

Alaskan coal proposed for near term mining is amenable to surface extraction and can be mined by dragline-based or truck-shovel based methods. Rail costs per short ton to the port of Seward from Matanuska and Hosanna Creek fields vary because of haul distances from $6 to $11. Coal loading costs at the port of Seward are in the range of $4 to $5 per short ton (1985 dollars). Therefore, total rail transportation combined with ship loading costs vary from $10 to $16 per ton. With large and increased volumes of coal, rail transportation and port costs could decline significantly from the above ranges.

The relative steaming time for Alaskan coal is competitive with other export coals in the Pacific Rim, and studies of the actual cost considering handling and combustion characteristics and inherent low sulfur and nitrogen contents indicate that, on a total dollar cost/Btu, Alaskan coal can be competitive in the Pacific Rim.

ACKNOWLEDGMENTS

The following individuals contributed information that was helpful in the preparation of this article: C.C. Hawley of Hawley Resource Group, Anchorage; P.D. Rao of the University of Alaska Mineral Industry Research Laboratory, Fairbanks; G.D. Stricker of the U.S. Geological Survey, Denver; R.B. Sanders, consulting geologist, Anchorage; D.M. Triplehorn, University of Alaska Department of Geology-Geophysics; J.E. Callahan, consulting geologist, Anchorage; J.C. Barker, U.S. Bureau of Mines, Fairbanks; J.F.M. Sims and M.D. Usibelli of Usibelli Coal Mine, Inc., Healy; D.E. Germer of Rocky Mountain Energy, Broomfield; Clyde Wahrhaftig, U.S. Geological Survey; J.V. Tucker of Diamond Alaska Coal Company, Anchorage; C.E. McFarland and B.J.G. Patsch of Beluga Coal Company.

COAL PROVINCES OF ALASKA

Most of Alaska's coal resources are in regions which can be defined geologically or geographically as provinces (Figure 3). These provinces can subsequently be divided into subprovinces, basins, fields, districts, and occurrences (Figure 5). This hierarchy offers a general framework for the naming and categorization of all coal-land areas in Alaska. On existing data, eight coal provinces can be recognized. Of these eight provinces, three---Northern Alaska, Nenana, and Cook Inlet-Susitna---contain most of the hypothetical and identified coal resources of the state. The others---Seward Peninsula, Alaska Peninsula, Yukon-Koyukuk, Upper Yukon, and Gulf of Alaska---have had historic production, contain some identified resources, and show potential for more discoveries. The true magnitude of economic coal resources in these latter provinces is not currently known. The Seward Peninsula province has significant lignite-subbituminous coal deposits in several areas. The Alaska Peninsula province has two important known coal fields---Chignik and Herendeen Bay. The Yukon-Koyukuk province includes deposits in the Kobuk, Nulato, and Tramway Bar fields. The Eagle field of east-central Alaska occurs in the Upper Yukon province and is related to a known regional fault structure, the Tintina fault. Other deposits of the Upper Yukon province include the Rampart field, the Chicken coal district, and various occurrences in the western Yukon Flats. The Bering River field is part of a poorly known belt of intergrading continental and marine Tertiary rocks in the Gulf of Alaska province.

Figure 5---NEAR HERE

Other coal occurs outside these recognized provinces, including occurrences in southwest Alaska (the Yukon-Kuskokwim region), southeast Alaska, and the Copper River basin. In addition, there are other isolated occurrences which are so poorly known that their geologic affinity and importance cannot be assessed.

COOK INLET-SUSITNA PROVINCE

A complex geologic basin which began to form in Early Tertiary time contains Alaska's most accessible and second largest coal resource base. Coal is mainly of Miocene age and subbituminous C rank, but varies from Paleocene to Pliocene age and includes bituminous and anthracite in the older units (Figure 6). The outlying Broad Pass field is mainly lignite. The recognized fields and districts of the province are listed in Table 3.

Figure 6, Table 3---NEAR HERE

Structure in the region ranges from gentle to complex. Two faults, the Castle Mountain and Moquawkie-Bruin Bay, were periodically active during basin formation and help divide the basin into smaller geologic units.

Rock units of the basin lie with angular unconformities on Jurassic-Cretaceous basement, and angular unconformities between the Paleocene-Oligocene and Oligocene-Miocene reflect episodic deformation during Tertiary time (Calderwood and Fackler, 1972; Kirschner and Lyon, 1973). Important coal-bearing units are the Tyonek, Beluga, and Sterling Formations of the Kenai Group of Miocene-Pliocene age and the Chickaloon Formation of Paleocene age.

Beluga Coal Field

The Beluga field is one of Alaska's most accessible resources of steam coal. Important and potentially mineable coal is found in the Chuitna, Capps, and Threemile districts within about 6-25 miles of port sites on Cook Inlet.

The first systematic study of the area (Barnes, 1966) identified and named thick beds from their outcrop localities as Capps, Chuitna, and Beluga beds and assigned the coal units to the middle Kenai Formation. Subsequent work (Calderwood and Fackler, 1972) has defined the Kenai as a group and assigned coal of the Chuitna and Capps districts to the Tyonek Formation and the Threemile district to the younger Beluga Formation, both of Miocene age. In the Chuitna district, study of outcrops along Chuitna River canyon and detailed drilling have aided identification of several seams. Seams in the area west of the Chuitna River---G, K, M, O, and Q---are shown in Figure 7. Seams in the area east of the Chuitna River are named by colors, that is, Brown, Yellow, Green, Blue, Red, and Purple. No definite correlation of the coal beds across the Chuitna River canyon has been made. The Brown bed is Barnes' Chuitna seam. The Red, Orange, and Blue seams were delineated mostly by drilling within a planned open pit area; they contain less ash than the Brown seam, with average contents of: 0.176 percent sulfur, 7.63 percent ash, and a range between 7,800 to 8,200 Btu/lb in heating value (Ramsey, 1981, p. 118, 120). Other reported analyses from the field indicate that the coal is subbituminous C, 6,200 to 9,500 Btu/lb, 0.1 to 0.7 percent sulfur, and contains from 3 to 30 percent ash. Bulk samples have shown that the coal is an excellent steam coal, performing satisfactorily in both conventional and fluidized bed boilers.

Figure 7---NEAR HERE

The current coal lessees have identified a number of mining sites in the Chuitna district both northeast and southwest of the Chuitna drainage. The combined tonnage of surface mineable low sulfur coal held by both Diamond Alaska and Placer U.S. totals approximately 1 billion tons at less than 6 bank cubic yards of waste for 1 short ton of coal. Engineering feasibility studies by the two companies range from mining one to 15 million tons of coal per year.

The Capps district has two potentially mineable seams---the Capps bed (upper seam, about 17 ft thick) and the Waterfall bed (lower seam, which ranges from 20 to 49 ft thick). Swift and others (1981) assigned a total of 750 million tons from 50,000 acres in the combined Chuitna and Capps districts.

Rao and Wolff (1981) reported that a sample of clean coal from the bottom 30 ft of the Waterfall seam analyzed at 8,327 Btu/lb (equilibrium bed moisture basis), 23.65 percent moisture, 7.81 percent ash, and 0.14 percent total sulfur, with 47.92 percent fixed carbon, 6.25 percent hydrogen, and 0.54 percent nitrogen. Other analyses confirm low sulfur subbituminous C coal in the Capps district.

In the Threemile district east of the Moquawkie fault several 10-ft seams can be mined from the Beluga Formation which dips southeast and toward the major Cook Inlet synclinal axis, reversing near Cook Inlet.

Other parts of the Beluga coal field are less well developed but thick coal locally occurs in the Drill Creek and Northern Extension district, where for example, the Drill Creek bed is as much as 65 ft thick and contains over 60 million short tons of coal.

Yentna Field

The coal seams exposed in the basin north of the Beluga field generally are in the Tyonek Formation and occur in the Conglomerate and Sandstone Members of the Tyonek Formation of Reed and Nelson (1980). Less well known than the Beluga field, the Yentna field contains drill proven resources in the Johnson Creek district and the outlying Canyon Creek district. Thick coal seams also crop out in the Fairview Mountain district, and thin seams in the Peters Hills and at other places.

At Johnson Creek, 5 to 7 seams strike N. 18°W. and dip 16 to 20° SE.; in the faulted Canyon Creek district, coal beds as much as 45 ft thick dip easterly at 15 to 20° to a fault where locally they are overturned. Quality reported is subbituminous C, 5,400 to 9,450 Btu/lb, 6 to 40 percent ash, 0.1 to 0.2 percent sulfur, and 20 to 30 percent moisture; several seams show 8,500 Btu/lb and relatively low ash (Blumer, 1981, p. 125). Identified resources to a depth of 250 ft and with less than 10:1 waste-coal ratio are greater than 500 million short tons in the combined Johnson Creek and Canyon Creek districts.

In the north part of the field in the Fairview Mountain district, thick beds (25 and 55 ft) were reported by Barnes (1966, p. C34-C36) in possibly slumped outcrops in Camp and

Sunflower Creeks.

Susitna Field

Extensive areas of coal which probably correlate with the Beluga or Sterling Formations of the Kenai Group underlie the Susitna Flats district. In the area north of the Castle Mountain fault, oil tests show seams up to 15 ft in Kenai Group rocks above a granitic base unit at about 2,000 ft depth; just south of the Castle Mountain fault, a test showed 301 ft of identified coal in 37 seams of Tyonek Formation in 8,500 ft of section. The oil test did not reach basement (Conwell and others, 1982).

The Little Susitna district has been reported to have a potential resource of 14.7 million tons of coal on the borderline between high-volatile bituminous and subbituminous A (Barnes and Sokol, 1959).

Broad Pass Field

The Broad Pass field occurs in a structural 'satellite' of the Cook Inlet-Susitna province, and contains late Tertiary (Pliocene?) coal-bearing strata in two districts. The Broad Pass Graben district lignite seams (Hopkins, 1951) are gently dipping (less 10°), 5 to 10 ft thick, 5,500 to 7,100 Btu/lb, 0.2 to 0.4 percent sulfur, and 10 to 20 percent ash. The Costello Creek district seams (Wahrhaftig, 1944; Rutledge, 1948) are mainly subbituminous A, 8,000 to 10,200 Btu/lb, 0.3 to 0.6 percent sulfur, and 7 to 21 percent ash. Identified resources of the Broad Pass field are 50 million short tons, and hypothetical resources are 500 million short tons.

Kenai Field

In the onshore part of the Kenai field (Barnes and Cobb, 1959), predominantly flat-lying seams from 2.5 to 20 ft thick contain an identified resource of 320 million tons of coal in the Beluga and Sterling Formations of the Kenai Group with Tyonek Formation strata found at depth in oil wells; hypothetical onshore resources are 35 billion short tons. The coal is subbituminous C, 6,500 to 8,500 Btu/lb, 0.2 to 0.4 percent sulfur and 3 to 25 percent ash.

Coals of both Beluga and Tyonek Formations underlie extensive areas of Cook Inlet. McGee and O'Connor (1975) estimated 532 million short tons of identified coal resources in beds more than 20-ft thick to a depth of 10,000 ft. This is part of the Kenai offshore field.

Small remnants of Tyonek Formation equivalent coal are locally preserved near Seldovia. This area includes the historic Port Graham Mine, first operated by the Russians in 1855.

Matanuska Field

The Matanuska coal field lies in the Matanuska Valley of southcentral Alaska, near the head of the Knik Arm of Cook Inlet, and about 50 miles northeast of Anchorage. This field contains the Anthracite Ridge district in the upper or east part of the valley, the Chickaloon district in the central part of the valley, and the Wishbone Hill district in the lower part of the valley. The Wishbone Hill district (Barnes and Payne, 1956) ranks second on historical coal production, having extracted about 7 million tons of bituminous coal for railroad, power plant, and domestic use prior to 1968. At least 17 million tons of surface mineable coal has been identified by recent work in the western and northeastern portions of the Wishbone Hill district. The higher ranked coals of the Chickaloon and Anthracite Ridge (Waring, 1936) districts have not been highly exploited due to their extreme structural complexity.

The moderately structurally complex Wishbone Hill district, like the Anthracite Ridge and Chickaloon districts, is defined by the known extent of the coal-bearing Chickaloon Formation of Paleocene age. The dominant structural feature of the Wishbone Hill district, a canoe-shaped syncline, creates the general outline of the Chickaloon Formation outcrop. The Chickaloon Formation is overlain unconformably by the Wishbone Formation of Eocene age, which in turn is overlain unconformably by the Tsadaka Formation of Oligocene age.

Mineable coal seams of the Wishbone Hill district are stratigraphically situated in the upper 1,200 to 1,500 ft of the Chickaloon Formation, where they generally occur in four groups (Figure 8). These groups, in descending order, have been named the Jonesville, Premier, Eska, and Burning Bed groups. The groups in the western portion of the district vary from 16 to 98 ft thick, and consist of numerous closely spaced seams interspersed with black carbonaceous shale and gray shale. In the eastern part of the district, the seams are not always concentrated in groups, and they generally have sharper contacts with boundary strata. The most prolific coal group, the Premier group, provides an excellent example of the west to east thickness increase of the coal groups. The Premier group contains 10 to 12 coal beds and ranges in thickness from about 90 ft in the western part of the district to about 260 ft in the eastern part of the district. The east-west stratigraphic variations of the coal and bounding strata are expected to result in less mining dilution in the eastern portion of the district.

Figure 8---NEAR HERE

The final quality of coal produced from the Wishbone Hill district can be significantly varied through alternation of mine sites and coal washing schemes. Run-of-mine coal quality is highly dependent upon the stratigraphic complexity of the mining section and the ability of the operator to mechanically separate coal from waste. The heat content of the run-of-mine coal may vary from 8,600 Btu/lb in the western Wishbone Hill district to over 11,000 Btu/lb in the eastern Wishbone Hill district.

In addition to the leases of Rocky Mountain Energy in the Wishbone Hill district, Evan Jones Joint Venture still holds the lease block surrounding the dormant Evan Jones Mine. Placer U.S. Inc. is the manager of this lease.

Overall, Wishbone Hill coal is high volatile B bituminous with 10,400 to 13,200 Btu/lb, 0.2 to 1.0 percent sulfur, and 4 to 22 percent ash. Coal from the Chickaloon district is low volatile bituminous (11,960 to 14,400 Btu/lb, 0.4 to 0.7 percent sulfur, 5 to 20 percent ash), and Anthracite Ridge coal is semianthracite to anthracite.

Hypothetical resources assigned to the field are 500 million short tons, with an identified resource of 150 million short tons.

NENANA COAL PROVINCE

Essentially all coal mined in Alaska recently came from the western end of the 'Nenana coal field' (as designated by Martin, 1919; and Wahrhaftig and others, 1969). Total production in 1986 was about 1.5 million short tons mined either for the domestic interior Alaska market or for export to Korea.

The Nenana coal province lies on the north flank of the Alaska Range and includes coal fields of or near the Nenana, Middle Tanana, and Minchumina basins. As presently recognized, the Nenana basin extends from 20 miles west of Healy to the Jarvis Creek field, about 140 miles although because of erosion and depositional centers, the coal fields of the basin are not continuous. The Middle Tanana basin just north of the Nenana basin has little potential for thick coal seams. West of the cross-basin Nenana fault, however, the Middle Tanana basin is thicker and coal-bearing, containing coal in three stratigraphic intervals above a schistose basement as shown in an oil test. An overlying Tertiary basin, the Minchumina, the Little Tonzona field, and several adjacent coal districts are of similar age and geologic setting as those of the Nenana and Middle Tanana basins. No deep testing is known to have been done in the deeper outlying parts of Minchumina basin.

The Nenana basin is the most important of the coal province, and has been divided into several fields.

These include the Western Nenana, Healy Creek, Hosanna Creek, Rex Creek, Tatlanika Creek, Mystic Creek, Wood River, Delta, and Jarvis Creek fields.

Coals of the Nenana basin are mainly Miocene and occur in the Usibelli Group (Wahrhaftig, <u>in press</u>) which contains the coal-bearing Healy Creek, Suntrana, and Lignite Creek Formations, and associated Sanctuary and Grubstake Formations (Wahrhaftig and others, 1969; Wahrhaftig, 1970a-h). The center of depositional basins for outcropping coal fields was probably slightly south of present outcrops and has been eroded, as the Healy Creek, Sanctuary, Suntrana, and lower Lignite Creek Formations are thicker to the south and are truncated by younger units to the north. In general, the oldest formation, the Healy Creek, is the most widely distributed formation of the Usibelli Group (Wahrhaftig and others, 1969), but as it filled an irregular basement, it and its coal units may be thick but lenticular. The coals of the Suntrana Formation tend to be more continuous.

<u>Hosanna Creek Field</u>[1]

Current coal production in Alaska comes from the Usibelli Coal Mine Poker Flats pit in the Hosanna Creek field, where Denton (1981, p. 139-142) reported a design reserve of 28 million short tons at a stripping ratio of 4.5:1. The coal mined comes from the designated 6,4, and 3 seams of the Suntrana Formation of Miocene age. Another minable reserve is projected in the Two Bull Ridge area of 38 million tons at 3.6:1 ratio (Denton, 1981).

[1]"Hosanna Creek" (correct spelling) is a former variant name for Lignite Creek (Brooks and others, 1907; Maddren, 1918; Martin, 1919) that is being readopted here.

The coal of the Hosanna Creek field is subbituminouc C of low sulfur content.

Healy Creek Field

Prior to about 1978, the major production of the Nenana basin came from Healy Creek and Suntrana Formations in underground and surface mines of the Healy Creek field. The field is in a faulted syncline and was estimated by Barnes (1967, p. B12-B13) to have measured resources of coal in beds greater than 10 ft thick of 300 million tons to a depth of 1,000 ft. The coal is subbituminous C.

Jarvis Creek Field

The Jarvis Creek field is located at the eastern margin of the Nenana basin near the Richardson Highway. Drilling has identified a strip-mineable reserve of 1 million tons based mainly on a 10-ft bed (Metz, 1981). The coal is most likely in the Healy Creek Formation (Wahrhaftig and Hickcox, 1955). Analysis of the 10-ft bed as reported by Rao and Wolff (1981) shows that it contains 20.58% moisture, 9.06% ash, 36.20% volatile matter, 34.16% fixed carbon, 1.05% total sulfur, 49.83% carbon, 5.84% hydrogen, 0.80% nitrogen, and 33.42% oxygen.

Identified resources of the Jarvis Creek field are 75 million short tons and hypothetical resources are 175 million short tons.

Little Tonzona Field and Associated Districts

The Tertiary coal found in the Little Tonzona field, and the Windy Fork, Middle Fork, Big Creek, and Cheeneetnuk River districts are included geologically with the Nenana coal province. The coals have been studied by Gary Player (written commun., 1970) and Sloan and others (1981). Beds are locally thick ---to 8.8 meters of clean coal in the Little Tonzona field and 5.3 meters of clean coal at Windy Fork.

An identified resource of 1.5 billion short tons has been estimated for the Little Tonzona field, which was drilled in 1980. Coal quality is similar to Nenana basin coal except that the Little Tonzona field coal contains about 1 percent sulfur.

Other Fields of Nenana Province

Other fields of the Nenana coal province have potential mineable resources; however, due to the remoteness from railroad or highway, they have not been mined or had coal pits designed.

a) Western Nenana (Teklanika) Field

The coal-bearing rocks of the Western Nenana field occupy a belt about 15 miles long and 3 miles wide that stretches from 3 miles west of the Nenana River on the east to the Sanctuary River on the west (Wahrhaftig, 1951). The strata probably include only the lower part of the Usibelli Group as present on Healy and Hosanna Creeks. Wahrhaftig (1951) estimated the total coal resources of this region at 250 million tons. Potentially mineable coal resources of the Western Nenana field to a projected overburden limit of 500 ft and including all beds greater than or equal to 2.5-ft thick are estimated to be at least 80 million short tons (Merritt, 1985).

b) Tatlanika Creek Field

The Tatlanika Creek field is one of the largest of the Nenana basin with outcrops of Usibelli Group strata covering an area of about 120 mi^2. A nearly complete section of the Usibelli Group from the Healy Creek Formation upward through the Grubstake Formation crop out on the south side of the field in an east-west trending belt near the confluence of Sheep and Moose Creeks. The Lignite Creek and Grubstake Formations together crop out over 80 percent of the field. It is estimated with relative high assurance that the Tatlanika Creek field contains at least 70 million short tons of potentially minable coal resources to a projected overburden limit of 500 ft and including all coal beds greater than or equal to 2.5-ft thick (Merritt, 1985).

c) Wood River Field

The Wood River field occupies an area of less than 40 mi^2 that stretches northeastward from Mystic Mountain and is generally restricted to the north and west side of the Wood River (Wahrhaftig and others, 1969). The belt includes a nearly complete stratigraphic section of the Tertiary Usibelli Group from the Healy Creek Formation upward to the Grubstake Formation. The series is exposed dipping from the schist ridge of Mystic Mountain beneath the gravels north of Coal Creek. At least 16 significantly thick coal seams with an aggregate thickness over 100 ft are exposed here. Potentially minable coal resources of the Wood River field to a projected overburden limit of 500 ft are estimated to be at least 65 million short tons (Merritt, 1985).

d) Rex Creek Field

The Rex Creek field is one of the smallest of the Nenana basin. The outcrop extent of the field is less than 25 mi^2 (Wahrhaftig and others, 1969). It is situated east of Rex Dome and west of Iron Creek, and is crossed by Rex and California Creeks. Coal-bearing rocks of the Healy Creek and Suntrana Formations crop out in the field. It is estimated with relative high assurance that the Rex Creek field contains at least 15 million short tons of potentially mineable coal resources to a projected overburden limit of 500 ft (Merritt, 1985).

e) Mystic Creek Field

The Mystic Creek field is located southwest of Mystic Mountain and about 2 miles west of Wood River, and is centered about 4 miles northeast of Keevy Peak. Outcrops of undifferentiated Tertiary Usibelli Group strata occur in an area less than 20 mi^2.

The Tertiary section is probably relatively thin (hundreds of feet?), rests unconformably on Paleozoic metamorphic basement rock, and in part at least may be correlative with the Healy Creek Formation. As many as 10 coal beds to 15 ft in thickness crop out locally on Mystic Creek. Potentially minable coal resources of the Mystic Creek field are estimated to be 10 million short tons (Merritt, 1985).

f) Delta Fields

The West Delta field contains outcrops scattered over an area of less than 40 mi^2 north of the West Fork of the Little Delta River, including exposures on Red Mountain, Newman, Dry, Slate, and Slide Creeks. Six coal beds to 5-ft thick crop out on Red Mountain Creek. A core hole drilled by Resource Associates of Alaska near Dry Creek revealed a relatively thin Tertiary section of about 130 ft with several thin coal beds. The undifferentiated Tertiary Usibelli Group strata here rests unconformably on Mississippian quartzite and schist basement. The sequence may be correlative at least in part with the Healy Creek Formation. It is estimated with relative high assurance that the West Delta field contains 5 million short tons of potentially minable coal resources (Merritt, 1985).

The East Delta field occupies an area of about 15 mi^2 between the Little Delta River and Delta Creek. The thin coals resemble those of the Jarvis Creek field and are found within currently undifferentiated Usibelli Group strata that are probably correlative with the lower part of the group, and possibly belongs to the Healy Creek Formation. It is estimated with relative high assurance that the East Delta field contains 5 million short tons of potentially mineable coal resources (Merritt, 1985).

NORTHERN ALASKA PROVINCE

The Northern Alaska province is not only the largest in Alaska, but probably is the largest coal resource of the United

States and ranks with the top 2 or 3 coal provinces in the world. The main identified resource is of Cretaceous age and includes coal in two groups (Figure 9).

Figure 9---NEAR HERE

The Nanushuk Group of both Early and Late Cretaceous age contains a series of widely distributed coals in western northern Alaska and extends as a tongue over halfway across the state. The coal ranges from bituminous to subbituminous and formed in a delta system which prograded northeasterly across northern Alaska. Most of the coal is in the Corwin Formation of uppermost Lower Cretaceous age which formed in a delta-plain environment (Ahlbrandt and others, 1979; Callahan and Martin, 1981; and Stricker and Roehler, 1981). The other coal of Cretaceous age is in the Colville Group of Upper Cretaceous age which locally overlies the Nanushuk Group.

In central-northern Alaska, lignite and coal occurs extensively in the Sagavanirktok Formation of Paleocene-Eocene age (Detterman and others, 1975). The geologic environment was deltaic. The coal-bearing unit is buried northerly by marine Tertiary rocks but is underlain, probably extensively, by Cretaceous coal. There is little data on the Sagavanirktok Formation lignite, but beds with shaly partings are reported to about 20 ft thick.

Because of the remoteness, the Northern Alaska province has not been systematically divided into fields, but recognized important resources are in the Cape Beaufort, Kukpowruk, and Wainwright fields.

The hypothetical coal resource of the Northern Alaska province is very large, on the order of 4,000 billion tons. Because of location and climate, it is unlikely that thin or deep seams will be mined in the foreseeable future. There are, however, significant resources in thicker beds at relatively shallow depth. As examples, in a total hypothetical resource of the Nanushuk

Group to a depth of 6,000 ft in the National Petroleum Reserve in Alaska, Callahan and Martin (1981) estimated 848,000 million tons. Within this tonnage are 202,300 million tons of coal in seams 5 ft thick or more above 1,000 ft, including in seams of 10 ft or more, 29,900 million tons of subbituminous coal and 29,600 million tons of bituminous coal.

Rank in the Northern Alaska province varies systematically with depth and with distance from the Brooks Range front. Locally the rank boundary between bituminous-subbituminous Nanushuk Group coal is 'covered' by subbituminous thin Colville Group coal. Coals of the Nanushuk Group south of the rank boundary are mainly high volatile C bituminous (10,000-13,500 Btu/lb, 0.1 to 0.3 percent sulfur, and 4 to 15 percent ash), and those north of the rank boundary are mainly subbituminous B (7,700 to 10,700 Btu/lb, 0.2 to 0.8 percent sulfur, and 3 to 20 percent ash).

Lisburne Field

Coal of Mississippian age crops out in the Point Lisburne area (Conwell and Triplehorn, 1976). The coals are found in the Kapaloak Formation of the Lisburne Group in seams less than 6-ft thick. The geologic structure in the field is fairly complex with most beds deformed and broken by faults. The coals are typically of low-volatile bituminous to semianthracite rank, 11,500 to 14,750 Btu/lb, 0.4 to 0.8 percent sulfur, and 2 to 18 percent ash. Hypothetical resources are 50 million short tons.

ALASKA PENINSULA PROVINCE

Coal of bituminous rank is widely distributed on the Alaska Peninsula in the Coal Valley Member of the Chignik Formation of Late Cretaceous age (Burk, 1965). Lignite occurs locally in the Unga Conglomerate Member of the Bear Lake Formation of Miocene age. Coal-bearing rocks of Tertiary age are probably also widely distributed at depth in the North Aleutian basin adjacent to Bristol Bay. For example, coal is reported in a 1,200-ft interval in the Port Heiden No. 1 well. The coal occurs in a detrital section with some volcanics and other carbonaceous units to about 9,000 ft, which in turn overlies a 6,000-ft Tertiary(?) volcanic section.

The coal of Cretaceous age is best known from the Herendeen Bay and Chignik fields. At Mine Harbor on Herendeen Bay, Conwell and Triplehorn (1978) report nine recognizable seams ranging from 1.5 to 6.4 ft thick; as reported, the 6.4-ft seam contains 4.6 ft of clean coal and 1.8 ft of bone. At Chignik River the same authors report a 7.8-ft seam of coal, including 4.7 ft of clean coal and 3.1 ft of bone and shaly coal.

Quality reported from the Herendeen Bay and Chignik River areas is high volatile bituminous B with about 20 percent ash. Conwell and Triplehorn (1978) determined that washing could raise the heating values of the coals to about 12,000 Btu/lb and reduce ash to about 10 percent.

Lignite is reported to occur in seams less than 8-ft thick and to range in heat content from 5,800 to 7,000 Btu/lb. These lignites are extensive on the peninsular mainland as well as on the northwest part of Unga Island.

The coal fields of the Alaska Peninsula province have not been studied in detail, but studies are sufficient to give an identified resource of 430 million short tons and a hypothetical resource of 3 billion tons.

GULF OF ALASKA PROVINCE

The chief coal field of the Gulf of Alaska province is Bering River. This field was described by Martin (1908), Barnes (1951), and mapped in detail by Miller (1961), and was subject to recent drilling. The coal field was first proposed for major development in the early 1900's. The field is attractive because it contains coal which ranges from medium- to low-volatile bituminous through semianthracite to anthracite in quality.

The rank, however, correlates with high deformation, and the coal has been squeezed into fold crests and faulted in a complex fashion. On the other hand, because the coal has been deformed locally into linear units as much as 30-ft thick, it may be possible, with detailed geologic and physical work, to delineate mineable deposits.

The coal occurs in the continental Kushtaka Formation of Eocene and Oligocene(?) age which intergrades with marine strata of the Kulthieth and Stillwater Formations. Although the field is shown as isolated, Kushtaka Formation rocks persist easterly into thrust fault slices mapped by D.J. Miller and others (Plafker, 1967). Coal is locally reported on the north side of Malaspina Glacier, and coal is probably more widely distributed in early Tertiary units than is presently recognized.

Bituminous coal in the field ranges from 11,000 to 15,000 Btu/lb, contains 0.1 to 1.0 percent sulfur and 2 to 30 percent ash.

The Bering River field has an identified resource base of about 160 million short tons in a hypothetical resource base of 3.5 billion short tons.

Another possibly important deposit of the Gulf of Alaska province is the Duktoth River district in the Robinson Mountains. This coal district includes coal beds of the Tertiary Kulthieth Formation to 6-ft thick.

YUKON-KOYUKUK PROVINCE

Thin beds of bituminous coal locally crop out along the north and east end of the complex Yukon-Koyukuk province defined by Patton (1973). These coals are in thick series of quartz conglomerate, sandstone, and tuff of Late Cretaceous age formed during uplift of the Brooks Range. The strata were formerly assigned to the Bergman Group.

Bituminous coal also occurs along the southeast flank of the province in intergrading marine and nonmarine strata assigned earlier, respectively, to the Nulato and Kaltag Formations (Martin, 1926). These strata are slightly older.

The coals of the north and east end of the province include the West and East Kobuk fields; those on the southeast flank include the Nulato field and many small occurrences of coal along the Yukon River.

Coal beds of the Kobuk fields have generally shallow dips (less 30°) defining broad open folds, and are locally steeply dipping near high-angle faults. Outcropping seams are typically 3-ft or less in thickness. The coals are of high-volatile C bituminous rank, 9,200-10,500 Btu/lb; 0.4 to 1.1 percent sulfur; and 7-35 percent ash.

The Nulato field has seams less than 4-ft thick with hypothetical resources of 50 million tons. The coals again are typically of high-volatile C bituminous rank, 9,100-9,750 Btu/lb, 0.2-0.6 percent sulfur, and 3-22 percent ash. Probable past production in the field has been less than 5,000 tons.

Coal in the northern part of the province has been reported from both north and south of the Kobuk River near Kiana and in occurrences northeast of Bettles. The thickest seam occurs in the Tramway Bar field on the Middle Fork of the Koyukuk River. Barnes (1967) states that the Tramway Bar field is an eastern extension of the coal-bearing rocks in the Kobuk area. Rao and Wolff (1980) sampled and analyzed coal from the main outcrop. Of the three outcropping seams, the thickest bed is 17.5 ft, and dips at about 56°. Analysis of the lower 4 m (13 ft) of the coal shows that it is of high-volatile B bituminous rank. Rao and Wolff found that washing the coal could very effectively reduce the ash content to acceptable levels.

Identified resources of the Tramway Bar field are at minimum 15 million short tons with hypothetical resources of 50 million short tons. Very little recent work has been done on the coal of the province, and it is at least possible that exploration would locally find significantly better coal.

UPPER YUKON PROVINCE

The two chief coal areas of the Upper Yukon province are what have generally been referred to in the past as the Eagle and Rampart fields. Other coal deposits are found in the Chicken district and at several sites in the western Yukon Flats.

A northeasterly series of basins, including the Eagle coal field lies generally along the Tintina fault of Alaska and Canada. Coal of subbituminous C and lignite rank occur in seams less than 5 ft thick and are exposed in broad open folds in Late Cretaceous and Tertiary strata. Range in quality reported is from 6,100 to 9,100 Btu/lb, 0.2 to 0.6 percent sulfur, and 2 to 20 percent ash. There is an identified resource of 10 million short tons and a hypothetical resource of 100 million short tons. An isolated occurrence near the Nation River possibly represents a faulted Tertiary coal or an isolated occurrence of coal of Paleozoic age. The coal at Nation River is bituminous.

The probable small isolated Circle district of Tertiary age lies near Circle Hot Springs on the continuation of the Tintina fault, and Tertiary continental sedimentary rocks are exposed in the Steese district.

A belt of Tertiary rocks structurally analogous to the Tintina belt with local coal lies along the northeasterly striking Kaltag fault. This belt includes the Rampart field, which contains Tertiary subbituminous to bituminous coal in beds typically less than 5-ft thick. Reported heat value ranges from 9,500 to 11,000 Btu/lb, sulfur is 0.2 to 0.5 percent, and ash varies from 8 to 15 percent. Hypothetical resources are estimated at 50 million short tons.

The Chicken district is located about 50 miles south of the Eagle field on a small tributary of the South Fork of the Fortymile River (Barnes, 1967). The Tertiary coal-bearing unit here has a potential area of only a few square miles. A 22-ft thick subbituminous bed dips near vertical in outcrop. A mine shaft was opened in the bed in the 1930's.

Barker (1981) reported on several coal occurrences in the western Yukon Flats. These Tertiary subbituminous to lignite coals were found on Coal Creek, a tributary to the upper Dall River, Ray River, Tozitna River, Hodzana River, Big Salt River, Lost Creek, and Hadweenzic River. Barker concludes that the coal resources in the marginal uplands of the region are significant to high, but that the coal, if present in the central basin is likely to be too deep for economic consideration.

SEWARD PENINSULA PROVINCE

The Seward Peninsula province contains a series of isolated fault and downwarp controlled deposits of Tertiary age (Hudson, 1977); although the deposits are relatively small, two contain thick seams of lignite-subbituminous coal, and unexplored areas have potential for significant tonnages of coal or lignite.

The deposits with drill-identified thick lignite or coal are Chicago Creek field and Boulder Creek district. Lignite also occurs in the Imuruk Lake and Kuzitrin River districts, and at isolated occurrences northwest of Nome. Two basins, McCarthy's Marsh district and Death Valley district have not been drilled, but from geophysical evidence are likely filled with Tertiary sedimentary rocks which could be coal-bearing.

The Chicago Creek field produced over 100,000 tons of coal around the turn-of-the-century to fuel local placer-mining operations. The seams occur in a narrow graben and dip from 45° to 70°. One seam is as much as 80-ft thick. The deposit has been evaluated over several years as a source of coal for power generation at Kotzebue and nearby communities. The potentially-mineable identified resources are about 4.7 million short tons of which 1.5 million tons can be mined at 1.7:1 stripping ratio and 3.2 million tons at 4:1. The coal, as received but with excess surface moisture, averages 6,800

Btu/lb, 8 percent ash, and 0.8 percent sulfur.

OTHER COAL-BEARING AREAS

Several other areas, not classed in a coal province, are known to contain significant amounts of coal or lignite. In most cases, these coal resources will likely remain undeveloped or be developed only for local use.

Copper River Field

Coals of the little-known Copper River field are found in the Oligocene Gakona Formation and the Miocene Frederika Formation (Moffit, 1954; Andreasen and others, 1964). Numerous lignite beds to 18-ft thick occur in isolated fault blocks, prisms, and erosional remnants. There are no known published analyses of the coal.

Southeastern Alaska

Coal is reported at several localities in southeastern Alaska (Barnes, 1967). Small quantities of high volatile B bituminous coal (9,900 to 10,700 Btu/lb, 0.8 to 1.5 percent sulfur, and 10 to 30 percent ash) in seams less 3-ft thick were produced from beds in the Angoon district, Kootznahoo Inlet, Admiralty Island. Lignite also occurs in the Admiralty and Kuiu districts. Although Kuiu district outcrops are isolated, they appear to be in a Tertiary basin about 60 miles long and up to 25 miles across which is mainly covered with volcanic rocks.

Southwestern Alaska

There are numerous reported occurrences of Cretaceous bituminous coals in the Yukon-Kuskokwim region of southwestern Alaska (Barnes, 1967), although the potential as a whole is largely unknown. Coal outcrops are found on the lower Yukon River, Innoko lowland, Eek River, Flat, Aniak River, and Nelson-Nunivak Islands west of Bethel.

Kodiak and Trinity Islands

There are also several localities on Kodiak Island and Sitkinak Island where Tertiary lignite coals crop out (Brooks, 1902; Anderson, 1969). The lignites are typically less than 1.5-ft thick and of very limited extent.

RECENT COAL ACTIVITY IN ALASKA

Alaska coal production, which is now accounted for entirely by that of Usibelli Coal Mine, Inc., reached an all-time high of about 1.5 million short tons in 1986. The coal was exported to South Korea and used to generate heat and electricity for Fairbanks and the railbelt region of Alaska (Table 4). Usibelli Coal Mine's tipple facility (Figure 10), which was damaged by a fire on November 18, 1985, resumed full production after only 11 days out of service. Transportation of coal to the Seward coal port facility (Figure 11) via the Alaska Railroad was interrupted for a two-week period in 1986 because of severe flooding in southcentral Alaska that locally damaged the rail lines.

Table 4, Figures 10-11---NEAR HERE

Usibelli Coal Mine (UCM) added two O & K RH 120C hydraulic shovels to its fleet of heavy machinery in 1986. These 234-ton giants are tracked vehicles with 16-yd^3 buckets and are manufactured by the Ornstein and Koppel Co. of Germany. One machine is used as a giant front-end loader in stripping overburden to expose coal seams. It permits stripping overburden that the dragline (Figure 12) can't reach. Deeper coal deposits can be mined, reserves are expanded, and stripping is more efficient. The second hydraulic shovel is rigged as a backhoe and is used to load coal. UCM also added a new D-11 Caterpillar that is used in road construction and to carve out benches for the dragline and drilling rigs.

Figure 12---NEAR HERE

A Taiwanese energy delegation toured UCM and Diamond Alaska's Chuitna site in 1986. The Taiwanese officials are considering an agreement to buy Alaska coal for electrical power plants to be built in the early 1990's. A 16-month study was completed in 1986 which showed that Alaska coal from the proposed Diamond Alaska Coal Company mine was suitable for burning in Japan's power plants and that it would be economical to use. The proposed $600 million mine is to be built about 50 miles southwest of Anchorage across Cook Inlet and about 15 mi northwest of the village of Tyonek. Diamond Alaska also drilled some 60 coal-exploration borings in 1986 to obtain additional coal-quality samples and geotechnical information. A 150-megawatt power plant has been proposed for construction near Diamond Alaska Coal Company's mining operation. The mine itself would use 50-MW, and 100-MW would go to railbelt utilities. The power plant may come on-line as early as 1991.

A second major coal-fired power plant (100-200 MW) was proposed in 1986 for the city of Nenana, located on the Alaska Railroad between Healy and Fairbanks. Electricity produced at the plant would be fed into the existing railbelt intertie to serve both Fairbanks and Anchorage. This plant is proposed to be operational in 6-8 years and would be the largest public-built project in Alaska.

The final report on the Western Arctic Coal Development Project was completed in 1986. This study was conducted from July 1984 to June 1986 to assess the potential of developing a coal industry in the western Arctic to supply coal to the northern and western coasts of Alaska. The study concluded that it was economically viable to mine the coal even at relative low levels of production with crude oil prices at or above $15 per barrel. As demand levels exceed 50,000 tpy, the economic price would be significantly lower.

The Alaska Coal Association (initially called the Coal Operators and Alaska Leaseholders or COAL) was formed in 1986 to push for the use of Alaska coal as an energy source. The association includes: Usibelli Coal Mine, Inc., Beluga Coal Company, Diamond Alaska Coal Company, Rocky Mountain Energy, Renshaw Engineering, and Hawley Resource Group. In addition to the Alaska Coal Association, a number of organizations perform various functions pertaining to studies of Alaska coal (Table 5).

Table 5---NEAR HERE

The Alaska Division of Mining and Geological and Geophysical Surveys in cooperation with the Alaska Coal Association published a new 'Map of Alaska's Coal Resources' in 1986 (Merritt and Hawley, 1986). The map can be purchased for $5 from the division's Fairbanks office (794 University Avenue, 99709).

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Table 1. Summary of coal resources in Alaska.

Resource Category	Total Resources (in millions of short tons)
Measured resources	6,500
Identified resources	170,000
Hypothetical resources	5,600,000

Table 2. Identified coal resources of Alaska by province.

	Millions of short tons	Rank
Northern Alaska province	150,000	High volatile bituminous and subbituminous; extensive lignite and minor anthracitic coals are not identified resources.
Cook Inlet-Susitna province		
Beluga and Yentna fields	10,000	Subbituminous
Kenai field (onshore only)	320	Subbituminous
Matanuska field	150	High volatile bituminous to anthracite
Broad Pass field	50	Lignite
Susitna field	110	Subbituminous
Nenana province		
Nenana basin proper	7,000	Subbituminous
Little Tonzona field	1,500	Subbituminous
Jarvis Creek field	75	Subbituminous
Alaska Peninsula province		
Chignik and Herendeen Bay fields, Unga I.	430	High volatile bituminous
Gulf of Alaska province		
Bering River field	160	Low volatile bituminous to anthracite
Yukon-Koyukuk province		
Tramway Bar field	15	High volatile bituminous
Upper Yukon province		
Eagle field	10	Subbituminous and lignite
Seward Peninsula province		
Chicago Creek field	4.7	Lignite

Table 3. Coal fields and districts of the Cook Inlet-Susitna province.

Coal field	Districts
1. Beluga	a. Chuitna
	b. Capps
	c. Threemile
	d. Drill Creek and Northern Extension
2. Yentna	a. Canyon Creek
	b. Johnson Creek
	c. Fairview Mountain
3. Susitna	a. Susitna Flats
	b. Little Susitna
4. Matanuska	a. Wishbone Hill
	b. Chickaloon
	c. Anthracite Ridge
5. Kenai	a. Kenai onshore
	b. Kenai offshore
	c. Seldovia-Port Graham
6. Broad Pass	a. Graben
	b. Costello Creek

Table 4. Market breakdown for 1985, Usibelli Coal Mine, Healy, Alaska* (from Bundtzen and others, 1986).

Site location	Coal (short tons)
Military power plants along rail belt: Clear and Eielson Air Force Bases and Ft. Wainwright	405,000
GVEA power plant: Mine mouth, Healy	150,000
Municipal Utilities System Power plant, Fairbanks	135,000
University of Alaska	52,500
Local home heating and Alaska Railroad	11,500
Suneel shipments to Korea	616,000
TOTAL	1,370,000

*Information provided by the Alaska Railroad, Fairbanks Municipal Utilities System, Golden Valley Electric Association, University of Alaska (Fairbanks) Physical Plant, and Usibelli Coal Mine, Inc.

Table 5. Organizations cooperating in Alaska coal studies with Division of Mining and Geological and Geophysical Surveys.

U.S. GEOLOGICAL SURVEY

Geologic mapping of coal-bearing formations and compiling data on Alaska's coal resources

U.S. BUREAU OF MINES

Geologic mapping and mineral-resource assessments

U.S. BUREAU OF LAND MANAGEMENT

Mineral resource assessments, land status, permitting

U.S. CORPS OF ENGINEERS

Confer on coastal developments, harbors

UNIVERSITY OF ALASKA MINERAL INDUSTRY RESEARCH LABORATORY

Performs coal analyses for DGGS and conducts research on character, use and development of coal in Alaska

UNIVERSITY OF ALASKA DEPARTMENT OF GEOLOGY AND GEOPHYSICS

Provides interns to work with DGGS, holds seminars on coal, confers with DGGS staff on coal programs

ALASKA POWER AUTHORITY

Interchange of fundings for coal resource and mining feasibility studies on coal use in remote areas of the state

ALASKA DIVISION OF MINING

Regulates State coal surface mining and reclamation program; DGGS provides coal-resource information to help determine what lands should be leased for coal and type of leases

ALASKA DEPARTMENT OF COMMERCE AND ECONOMIC DEVELOPMENT, OFFICE OF MINERAL DEVELOPMENT

With DGGS jointly makes an annual survey of the mineral industry and publishes a formal report on mineral activities

ALASKA NATIVE VILLAGES AND REGIONAL CORPORATIONS

Have supported State coal exploration projects and feasibility studies on the use and development of coal

BOROUGH GOVERNMENTS

Have cooperated on and supported coal and mineral resource studies

FIGURE CAPTIONS

Figure 1...Alaska's 1:250,000-scale quadrangles with known occurrences of coal and the major coal-resource regions of Alaska.

2...Comparison of world, U.S.A., and Alaska coal resources.

3...Location of Alaska's coal provinces, basins, fields, and occurrences.

4...Ocean-freight distances in miles from Seward, Alaska to potential Pacific Rim markets. Base from Defense Mapping Agency's (Washington, D.C.) map of 'Great circle distances and azimuths from Fairbanks, Alaska to all points on the Earth's surface.'

5...Hierarchy of coal-area names used in the classification of Alaskan coal deposits.

6...Generalized age and correlation diagram for Tertiary coal-bearing rocks of the Cook Inlet-Susitna province (modified after Magoon and others, 1976).

7...Generalized stratigraphic section of Center Ridge area, Chuitna district, Beluga coal field showing major minable seams (courtesy Beluga Coal Company).

8...Generalized coal section of upper Chickaloon Formation, Wishbone Hill district, Matanuska coal field (from Hawley and others, 1985).

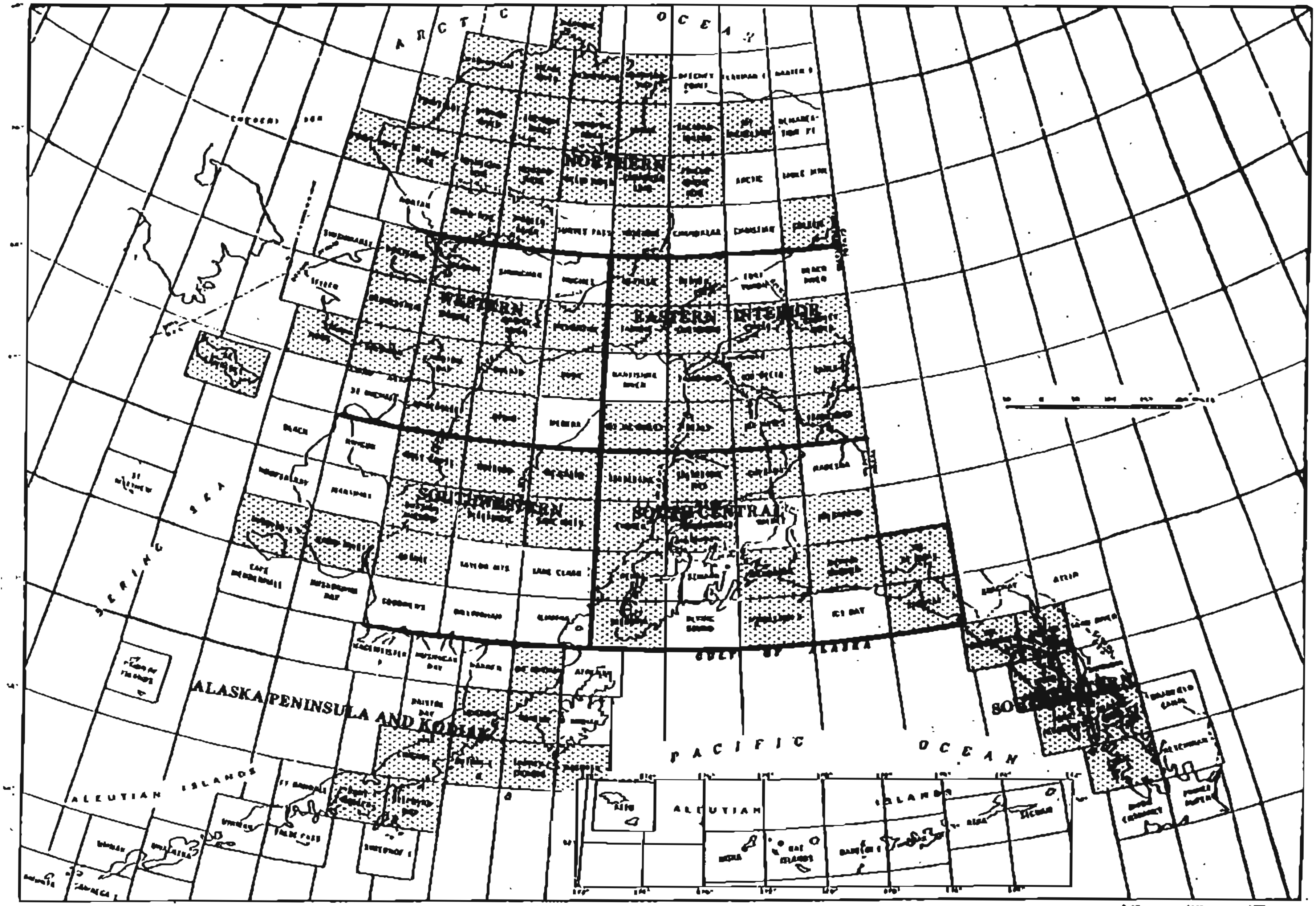

ARCTIC OCEAN
NORTHERN
WESTERN
EASTERN INTERIOR
SOUTHWESTERN
SOUTHCENTRAL
ALASKA PENINSULA AND KODIAK
BERING SEA
GULF OF ALASKA
PACIFIC OCEAN
ALEUTIAN ISLANDS

Figure 1

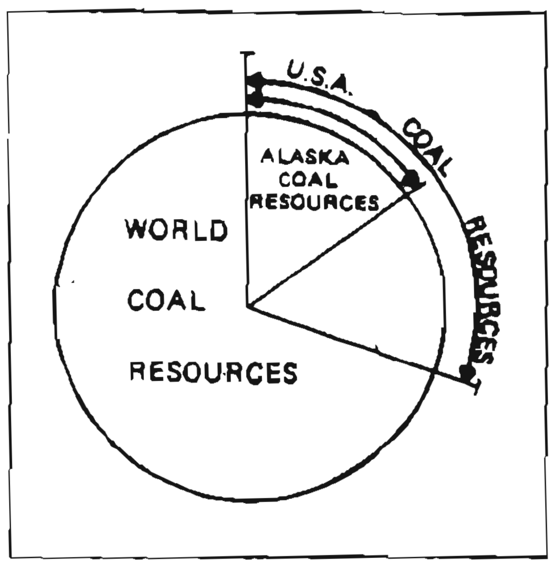
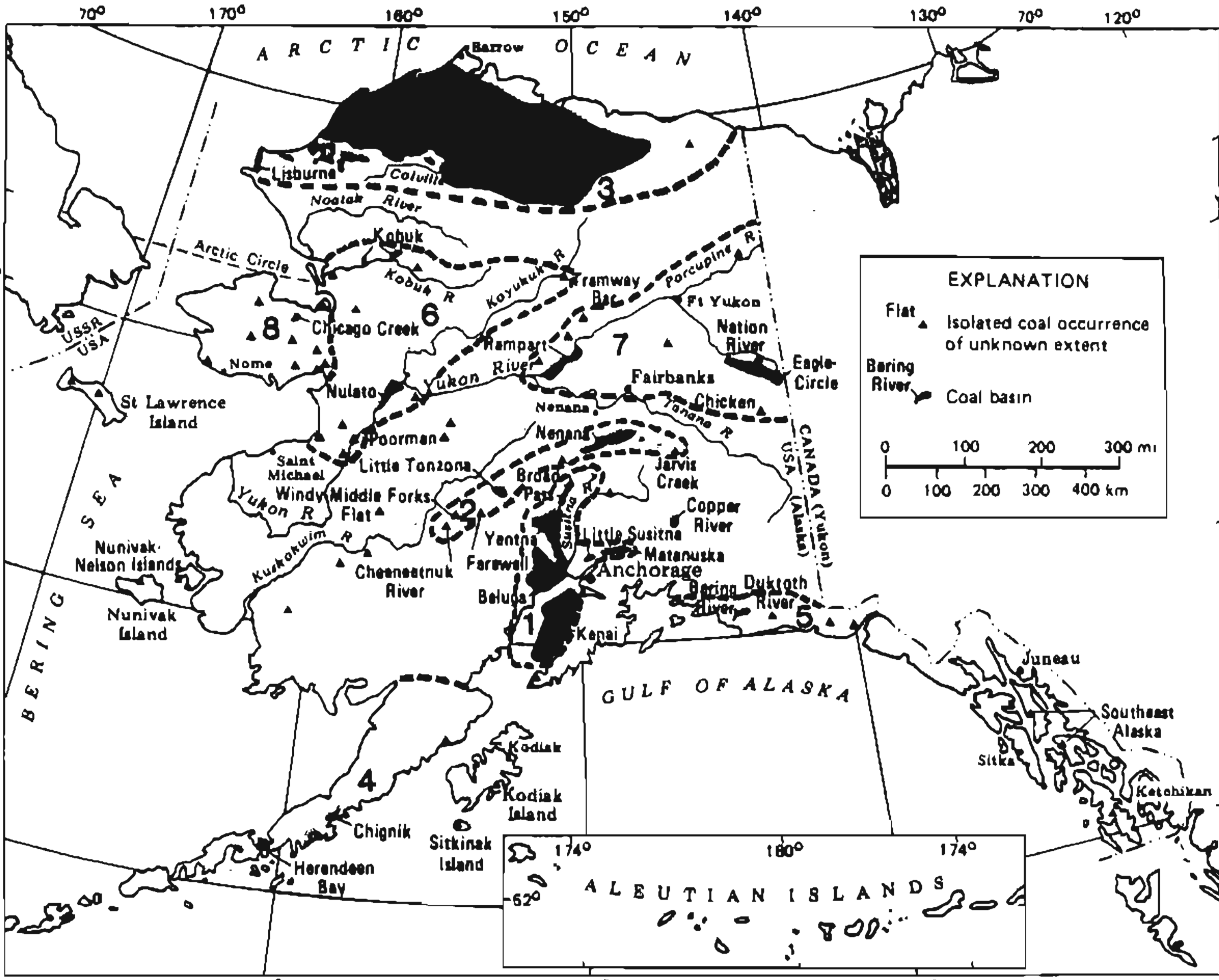

U.S.A. COAL RESOURCES
ALASKA
COAL
RESOURCES
WORLD
COAL
RESOURCES

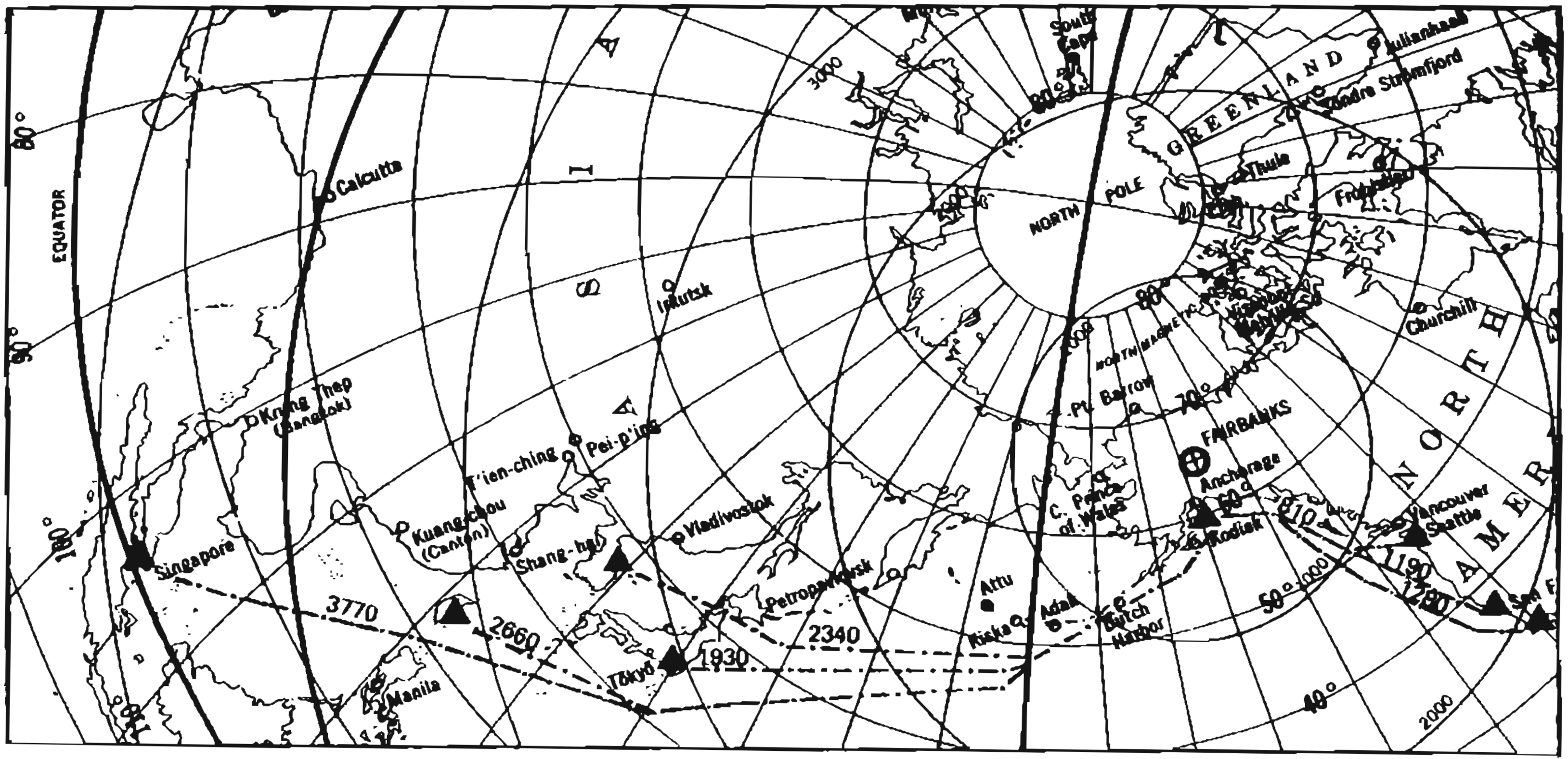
Figure 2



COAL PROVINCES OF ALASKA

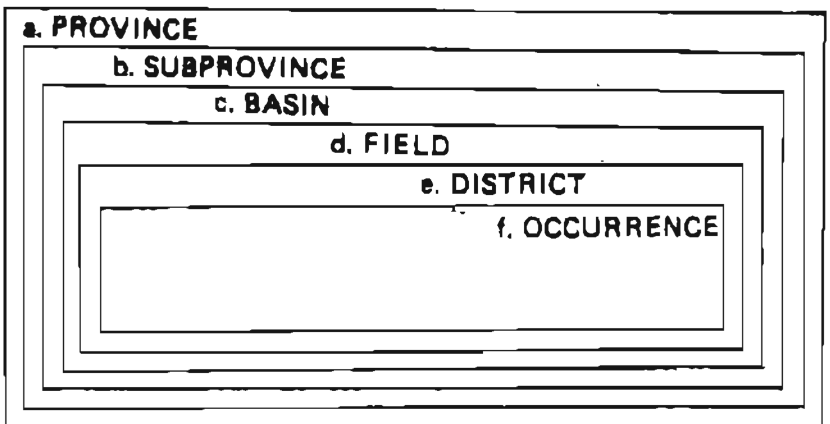
1-Cook Inlet-Susitna	3-Northern Alaska	5-Gulf of Alaska	7-Upper Yukon
2-Nenana	4-Alaska Peninsula	6- Yukon-Koyukuk	8-Seward Peninsula

Figure 3



EQUATOR
Calcutta
Irkutsk
Krung Thep (Bangkok)
Pei-p'ing
T'ien-ching
Kuang-chou (Canton)
Shang-hai
Vladivostok
Petropavlovsk
Singapore
Manila
Tokyo
3770
2660
1930
2340
Attu
Kiska
Adak
Dutch Harbor
NORTH POLE
NORTH MAGNETIC POLE
GREENLAND
Thule
Julianehaab
Sondre Stromfjord
Frobisher
Churchill
Pt. Barrow
C. Prince of Wales
FAIRBANKS
Anchorage
Kodiak
810
1190
1280
Vancouver
Seattle
NORTH AMER
3000
2000
1000
80°
70°
60°
50°
40°

Figure 4



a. An extensive area containing similar coal-bearing rocks

b. A relatively large area forming a contiguous part of a province

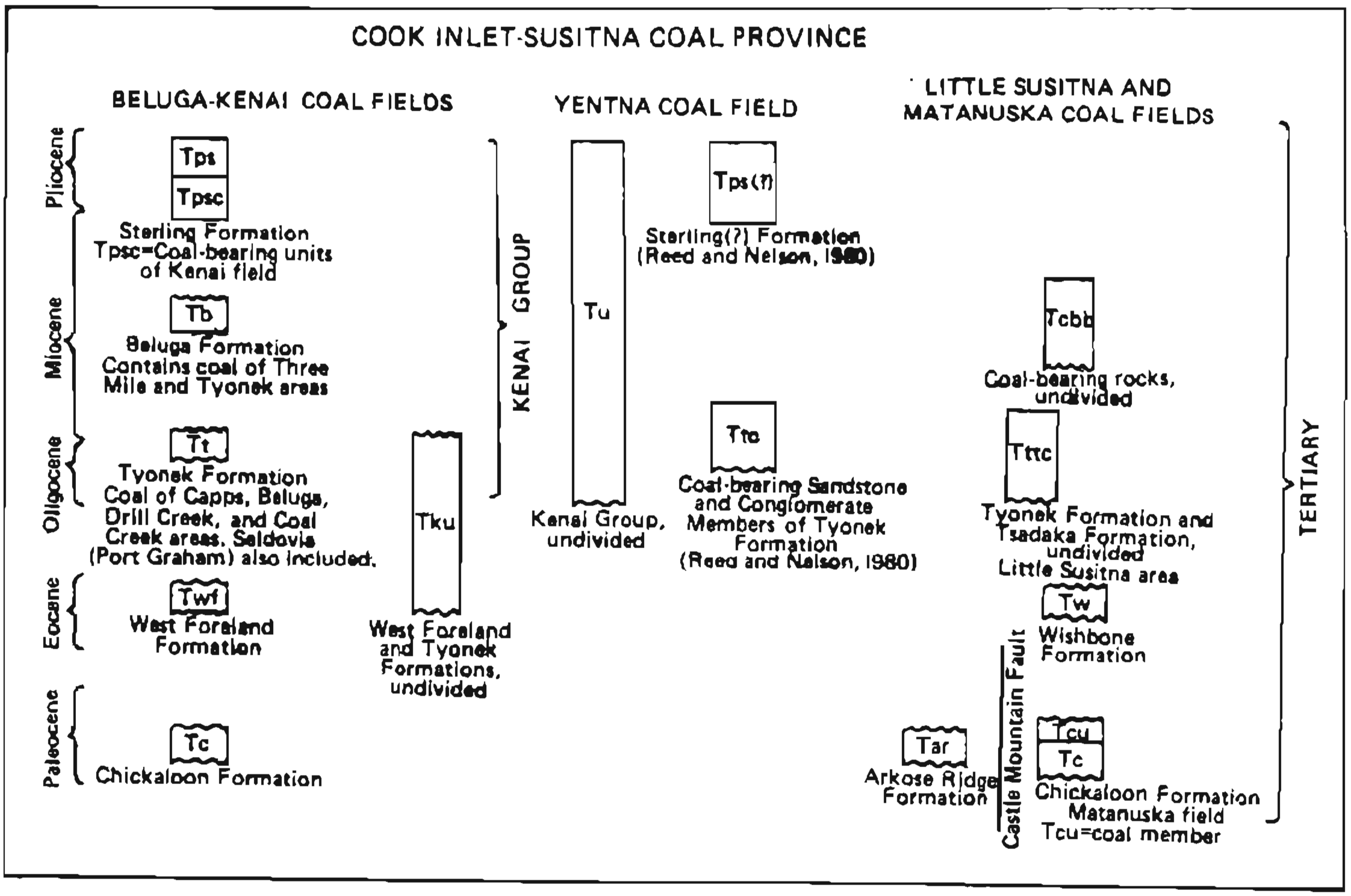
c. An area containing one or more coal fields or forming a distinct part of a province

d. An area having high resource potential and containing one or more known coal beds of minable mineable thickness and quality

e. An area forming part of a coal field or an isolated area having less probable resource potential than a coal field

f. A site where one or more typically thin and discontinuous coal beds crop out

Figure 5



COOK INLET-SUSITNA COAL PROVINCE
BELUGA-KENAI COAL FIELDS
YENTNA COAL FIELD
LITTLE SUSITNA AND MATANUSKA COAL FIELDS
Pliocene
Miocene
Oligocene
Eocene
Paleocene
Tps
Tpsc
Sterling Formation
Tpsc=Coal-bearing units of Kenai field
Tb
Beluga Formation
Contains coal of Three Mile and Tyonek areas
Tt
Tyonek Formation
Coal of Capps, Beluga, Drill Creek, and Coal Creek areas. Seldovia (Port Graham) also included.
Twf
West Foreland Formation
Tc
Chickaloon Formation
Tku
West Foreland and Tyonek Formations, undivided
KENAI GROUP
Tu
Kenai Group, undivided
Tps(?)
Sterling(?) Formation (Reed and Nelson, 1980)
Ttc
Coal-bearing Sandstone and Conglomerate Members of Tyonek Formation (Reed and Nelson, 1980)
Tcbb
Coal-bearing rocks, undivided
Tttc
Tyonek Formation and Tsadaka Formation, undivided
Little Susitna area
Tw
Wishbone Formation
Castle Mountain Fault
Tar
Arkose Ridge Formation
Tcu
Tc
Chickaloon Formation
Matanuska field
Tcu=coal member
TERTIARY

Figure 6

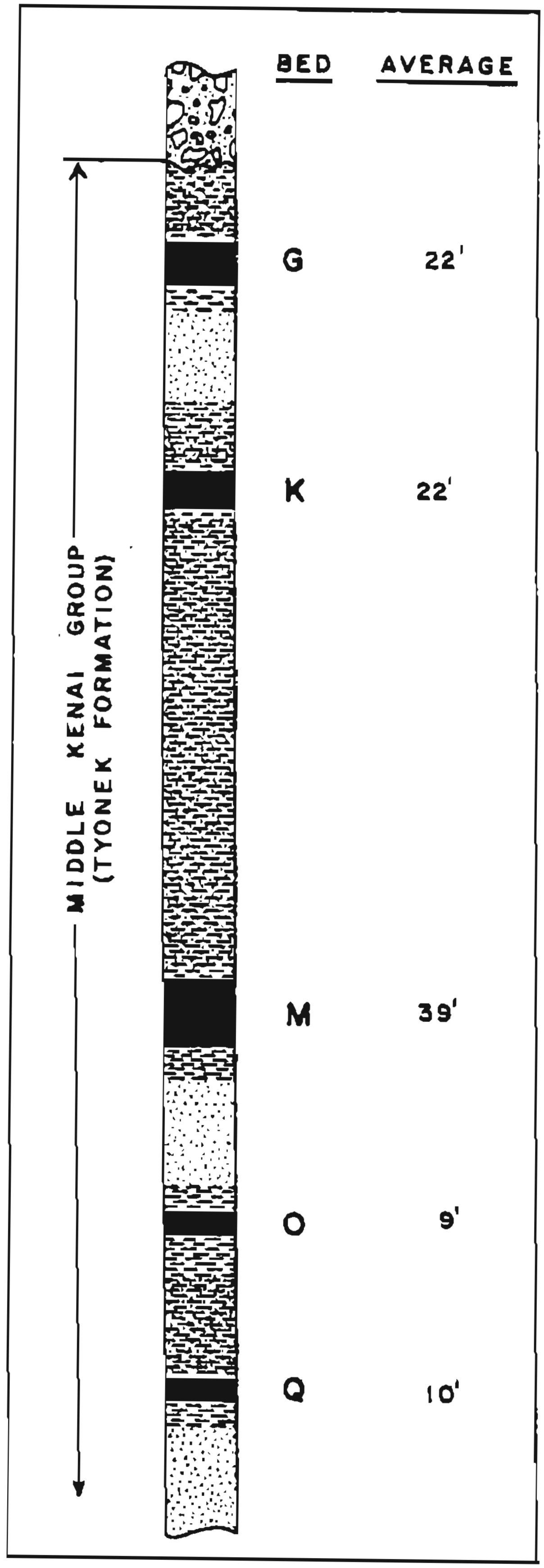
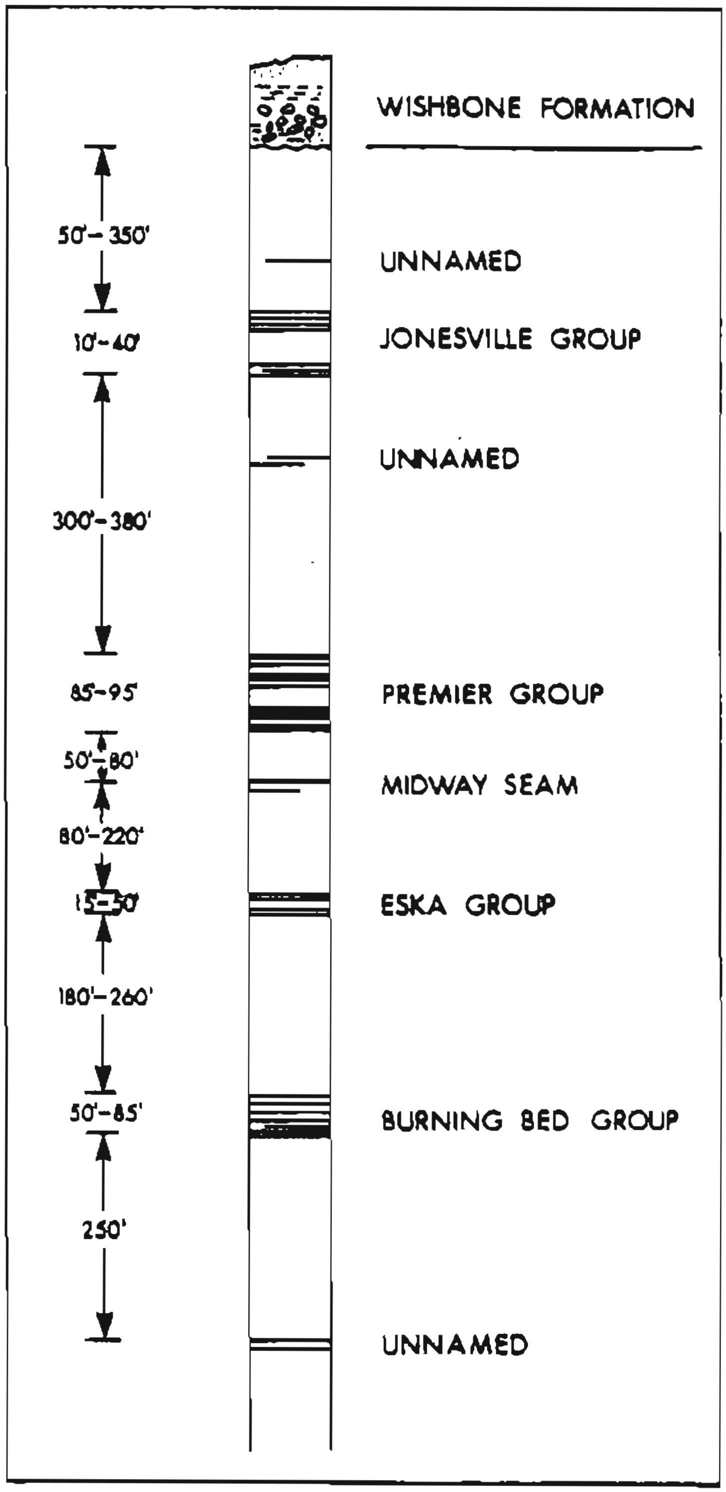
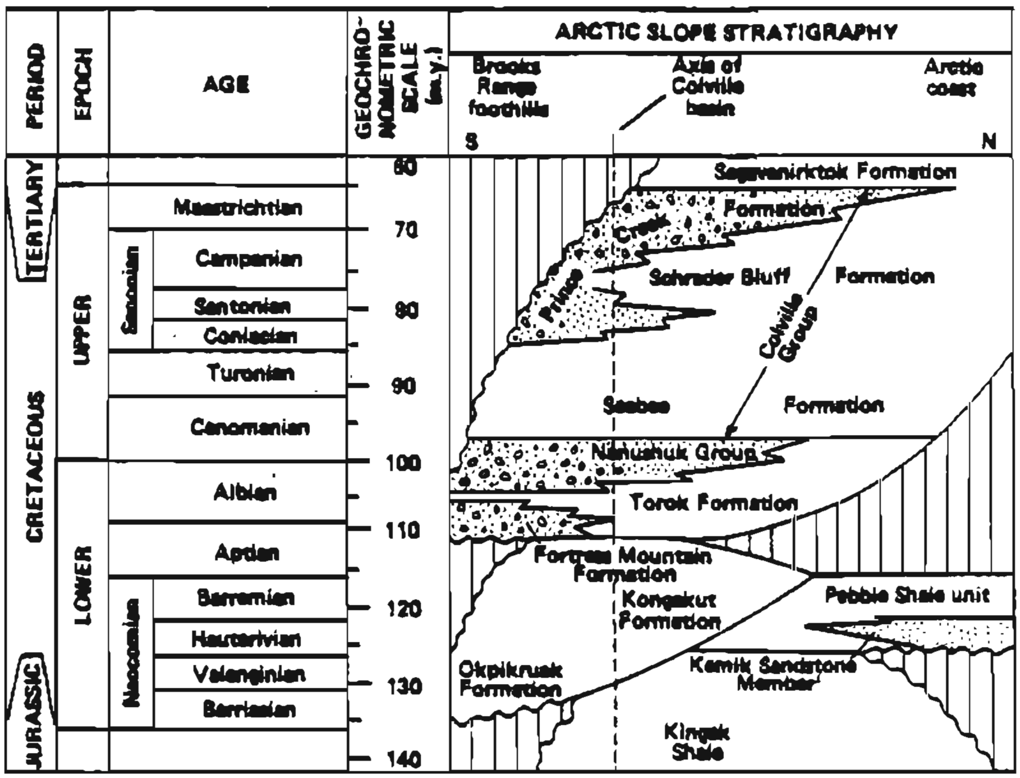

BED AVERAGE
MIDDLE KENAI GROUP
(TYONEK FORMATION)
G 22'
K 22'
M 39'
O 9'
Q 10'

Figure 7



WISHBONE FORMATION
50'–350'
UNNAMED
10'–40'
JONESVILLE GROUP
UNNAMED
300'–380'
85'–95'
PREMIER GROUP
50'–80'
MIDWAY SEAM
80'–220'
15'–50'
ESKA GROUP
180'–260'
50'–85'
BURNING BED GROUP
250'
UNNAMED

Figure 8



NOTE: DEEP OIL TESTS SHOW THAT MISSISSIPPIAN SEMIANTHRACITE AND ANTHRACITE COALS ARE WIDELY DISTRIBUTED ACROSS NORTHERN ALASKA. MISSISSIPPIAN COAL-BEARING STRATA OF THE KAPALOAK FORMATION CROP OUT ON THE LISBURNE PENINSULA, AND MISSISSIPPIAN COAL-BEARING STRATA OF THE KEKIKTUK CONGLOMERATE CROP OUT IN NORTHEASTERN ALASKA.

Figure 9

Figure 10

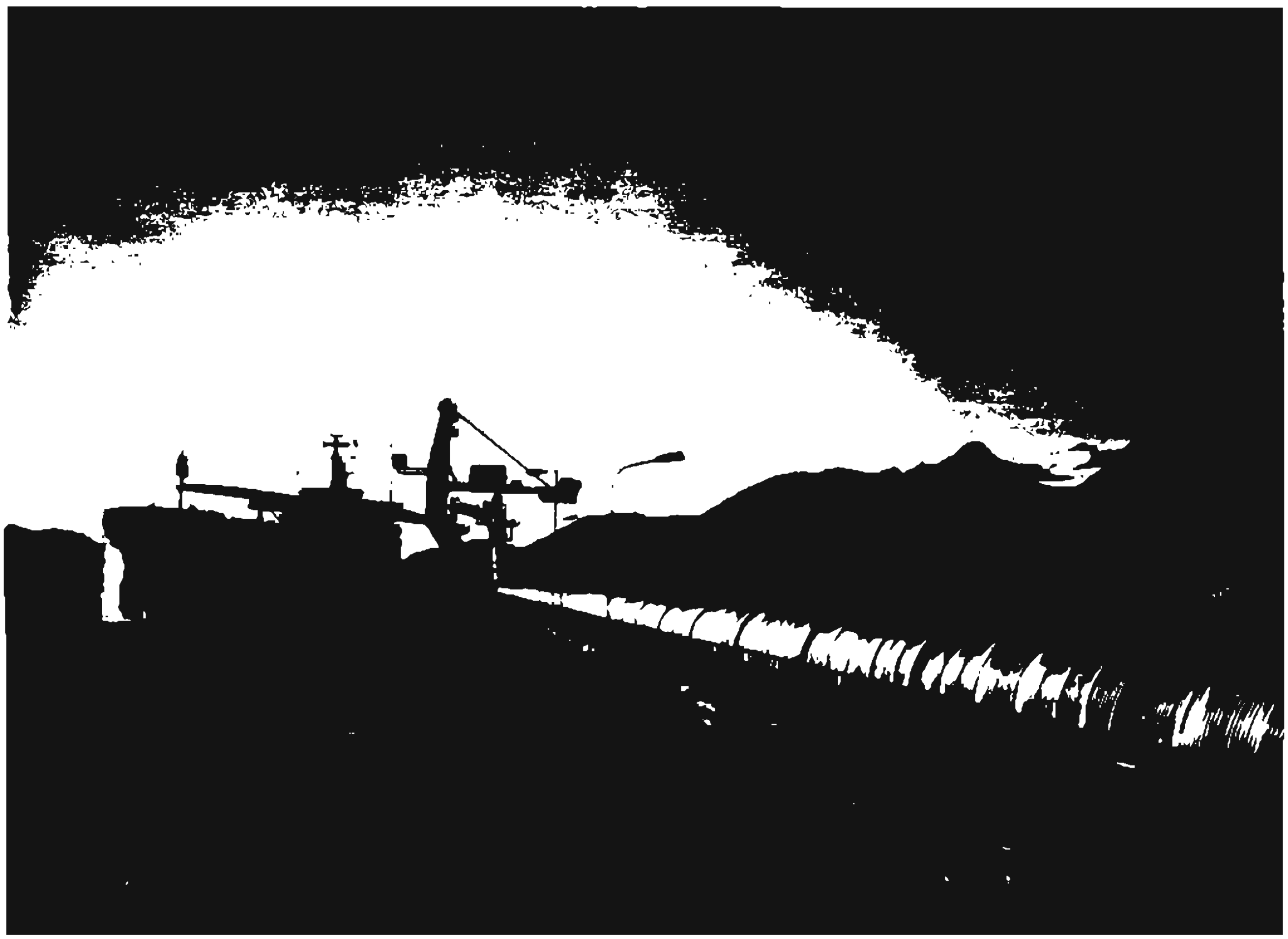


Figure 11

Figure 12