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SLIDE PRESENTATION ON ALASKA COAL

[Slides and map for this presentation are available for inspection through the Resource Information Section, DGGS, 794 University Avenue, Fairbanks, Alaska, 99709 (907) 474-7147]

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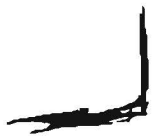
This slide presentation is intended for non-technical audiences. A more technical orientation can be achieved with a moderate adjustment of the basic format, and addition or subtraction of slides according to need. Additional coal slides are available in the coal-slide library, ADGGS Coalfield Investigations Section, Fairbanks, Alaska.



ALASKA COAL

SLIDE SHOW PRE-TALK

I'm here to talk to you about Alaska's coal resources. Most of what I've been doing over the last 7 years has to do with Alaska's coal. That is the branch of geologic studies that I have chosen for my career.

At the moment, and for the last 4 years off-and-on, I've worked for the State of Alaska Division of Geological and Geophysical Surveys. One of our jobs at the state survey is to locate, map and assess mineral and fuel resources in the state. Coal is a fuel resource.

Much of my work with the state survey has been with assessment of the coal resources of Northwest Alaska. That area is roughly right through here. (MAP) In addition to that work, I have visited coal locations Here - at chicken, at Rampart..briefly..Here, above Galena and on down the Yukon to below Kaltag, Here - on the Kenai Peninsula, the Little Tonzona field, Here - at Preacher Creek, and Broad Pass - The Nenana field, and Cape Dyer on the Lisburne Peninsula.

The slides that I'll show you soon are a collection of State Geological Survey slides, and some donated by colleagues of mine. I have pictures from most of the coal locations in Alaska.

If you will look at this map of Alaska, you will see several colored areas. These represent known coalfields and occurrences in the state. Compared to this huge area, those blobs and dots might not be too impressive, but let's look at some figures:

You have several handouts there. One of them is the State Geological Survey Circular No. 17, "Coal Resources of Alaska". The other, "The Coal Option..energy for Alaska's future" is put out by an organization of Alaskan coal developers call C.O.A.L. Both contain interesting basic information about our coal resources and their uses.

In I.C. 17, on page 4, you will see that coal resources of Alaska, based on known coal and estimated tonnage amounts to over 5½ trillion short tons. Alaska contains half as much coal as the total lower 48. (P.1, I.C. 17). Before going on, I want to give you a brief rundown of some of the most common terms used in discussing coal in Alaska:

Bone Coal: Impure coal containing a high percentage of clay or other fine-grained mineral matter.

Coal Bed: All the coal, including partings, lying between roof rock and floor rock.

Coal Seam: Sometimes used instead of coal bed. Not an officially recognized term, but commonly used anyhow. In common usage, it can either mean a very thin coal bed, or one or more of the coal portions of a bed containing partings.

Parting: A layer of non-coal material, such as clay or sandstone, or shale, that occurs within a coal bed, and does not exceed the width of the coal lying above or below it.

Hanging Wall: That portion of the enclosing rock units that is in direct contact with the top of the coal bed. (roof rock)

Footwall: That portion of the enclosing rock units that is in direct contact with the bottom of the coal bed. (floor rock)

Other terms that are unfamiliar may come up as we go along, so if I use a term that you are not familiar with, don't hesitate to ask me what it means. It's hard to remember sometimes that what might be an everyday term for me might be meaningless to someone else.

For a complete glossary of terms, I am giving you this handout. (Glossary section from Coal Resource Classification of the U.S. Geological Survey, Geological Survey Circular 891.

Now, the next thing that I want to explain is the relationship between the rank of a particular coal and its age. With a few exceptions, which I will talk about as individual cases later, the rank or heating valve of a coal depends on how old it is. The older the coal, generally speaking, the greater it's heating value will be. Look through your handouts for the one that says "Types of Coal". The last page has a geo-time scale. Look at your time scale. Most Alaskan coals are either of Cretaceous age, or Tertiary age.

The largest of these are:

1) Northern Alaska
2) The Cook Inlet - Susitna Lowlands, and
3) the Nenana Trend...which includes Jarvis Creek and the Little Tonzona River coal.

Coking and Metalurgical grades of coal are found in certain seams in the Lisburne Peninsula field, the Northern field, the Nulato field, the Bering River field, the Matanuska field and the Herendeen Bay field.

There have been studies in the past, and recently, regarding some of the potential uses for Alaska's coal. Some of them are for products such as briquettes, synthetic fuels, amonium sulfate (fertilizer), light oils and tar, and coke. Other studies have looked at the use of some coal deposits as fuel sources for villages,...and for export to Pacific Rim nations such as Korea, Japan and Taiwan.

The energy equivalent of the known coal in Alaska is many orders of magnitude greater than all of the oil that can ever be recovered from Prudhoe Bay. Alaska's coal resources are the equivalent of between 7 and 20 trillion barrels of oil...which equals 700 to 2000 oilfields the size of Prudhoe Bay.

Rank..this is a classification system of coal based on it's heating value, or British Thermal units per pound, - based on its dry, mineral matter free heat value, fixed carbon percentage and volatile matter component.

BTU = British Thermal Unit: A BTU is the amount of heat required to raise the temperature of one pound of water one degree farenheit, at or near its point of maximum density at 39.1°F.

Coal: A readily combustible rock containing more than 50% by weight and more than 70% by volume of carbonaceous material, including water.

Coal Rank Classifications

Lignite: BTU Range from less than 6,300 BTU/lb to 6,300 BTU/lb for Lignite "B", and from 6,300 BTU to 8,300 BTU/lb for lignite "A".

Subbituminous: (Range = 8,300 BTU/lb to 11,500 BTU/lb.)

- Subbituminous "C" = 8,300 BTU/lb to 9,500 BTU/lb
- Subbituminous "B" = 9,500 BTU/lb to 10,500 BTU/lb
- Subbituminous "A" = 10,500 BTU/lb to 11,500 BTU/lb

Bituminous:

- Bituminous "C", (high volatile) ≥11,500 <13,000, commonly agglomerating
  ≥10,500 <11,500, agglomerating
- Bituminous "B", (high volatile) 13,000 - 14,000, commonly agglomerating
- Bituminous "A", (high volatile) 14,000 and above, commonly agglomerating
- Bituminous (Medium volatile) >14,000 BTU/lb F.C.% ≥69%
- Bituminous (Low volatile) >14,000 BTU/lb F.C.% ≥78%

Semi Anthracite: (non agglomerating) F.C.% ≥86%

Anthracite: (non agglomerating) F.C.% ≥92%

Meta-Anthracite: (non agglomerating) F.C.% ≥98%

100% Fixed Carbon is graphite or diamond.

Most of you are familiar with the coal that is mined in Healy at the Usibelli Mine. Usibelli coal is ranked between Subbituminous "C" and "B".

Most of the coal found in Alaska is either Tertiary or Cretaceous in age.

There are two exceptions to that. One is the coal on the Lisburne Peninsula, near Point Hope. That coal is Mississippian in age...350 million years old. The other exception is the coal exposed in the cliffs on the Yukon called the Palisades or the "Bone Yard". That coal is hardly more than compressed wood in

some cases. It is in the first stages of coalification. The coal is Pliocene in age...5 million years old.

The Cretaceous period of geologic time is designated as the span of years between 140 million years B.P. and 65 million years B.P.

The Tertiary Period of geologic time is designated as the span of years between 65 million years B.P. and 1.8 million years B.P.

During the long time span, of over 130 million years, conditions favored coal formation in Alaska. Not all at once, and not continuously, but over-all, conditions were good. In order to form thick coal beds, you must have rapid plant growth and death in an environment where the plant remains accumulate great thickness without decaying much. This requires a lack of oxygen--such as in stagnant water. Huge swamp-forests must have covered great areas of land over long periods of time.

In order to appreciate the amount of vegetable matter that it takes to produce coal, consider this...it takes about 9 feet of peat, which is partially decomposed and compressed vegetable material, to produce 1 foot of subbituminous rank coal. It takes double that amount to produce 1 foot of high rank coal such as low volatile bituminous.

As coal forms from dead vegetation, going from stage to stage, the necessary component is pressure. New material accumulates on top of old, and the layers get buried deeper and deeper as time goes on. With increased depth of burial, more moisture is squeezed out, and some heat is generated. Compression, heat, compaction, loss of moisture and volatiles all change the nature of the material. What remains is a concentrated carbon-based product similar in molecular structure to crude oil. The more advanced the metamorphism, or change, in the coal, the higher the rank.

Pressure and compaction from deep burial is the most common agency of coal upgrading, but there are other natural events that can upgrade a coal to higher rank. In the process of uplifting mountains, subsiding basins, lateral compression through fault and tectonic activity; sediments that were once

flat-lying become folded and deformed. The amount of deformation varies with the severity of the deforming agency. The kinds of stress produced by folding and faulting also produce heat and compression. This heat and compression can raise the rank of a coal in a similar manner to deep burial. Another way of upgrading a coal occurrence is through the close intrustion of an igneous rock mass from great depth. If hot magma rises through weak spots in the earth's crust, and happens to come close to a coal deposit, the heat from this mass of hot rock can thermally upgrade the coal by driving off volatiles in the form of gasses, and moisture, and causing molecular re-organization.

Soon we can zero in on individual coal occurrences in Alaska. But first, let me give you a brief overview (Use map).

About 55 percent of Alaska's known coal is of Bituminous rank...40 percent is subbituminous, 5 percent is lignite, and less than 1 percent is semi-Anthracite and Anthracite.

Bituminous coal is found in: (Use map).

The Northern field
The Lisburne field
The Kobuk field
The Nulato field
The Matanuska field
The Bering River field
The Chignik field
At Herendeen Bay, and at
Tramway Bar above Bettles

Subbituminous coal is found in

The Northern field
The Rampart field
The Yukon flats uplands...and probably under most of the flats.
In the Eagle field
The Nenana field and Jarvis Creek
The Little Tonzona field

Subbituminous coal is found in (Continued)

The Beluga field

The Little Susitna field and
The Kenai field, underlying most of the southern Kenai Peninsula.

Lignite is found in the: Palisades--Alaska's youngest deposits.
(Fossil trees, mastodon + mammoth, etc.)
Seward Peninsula...Chicago Creek and other places
The Broad Pass field - near Mt. McKinley
The Herendeen Bay field
The Little Tonzona field
Unga Island --
Chicken--and scattered around the state.

Semi Anthracite and Anthracite:
Are found primarily in the Bering River and Matanuska fields, although small, isolated occurrences can be found elsewhere on occasion--where localized conditions have upgraded small bodies of coal, or portions of a coal bed.

The figure--Five trillion, 600 billion tons of coal in Alaska--may be conservative. There may be millions or billions more. I say this because there has been very little systematic coal exploration in Alaska. Most of the identified and reported coal occurrences in Alaska are known as a by-product of other mining and prospecting efforts. Many of these coals were exploited on a small scale around the turn of the century for use in mining operations-mostly placer- and as fuel for river steamers along with the usual cord-wood. Most of these small coal-mining ventures close down after the California oilfields started producing, when gasoline became available, in 1903--and haven't been looked at since. Many have never been mapped, drilled or sampled, especially in the interior. It is reasonable to assume that there are still many coal deposits lying undiscovered out there. It should be one of our biggest priorities to locate and investigate; map and sample; and estimate reserves for one of the biggest fossil fuel banks in the world.

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) semianthracite 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.

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 OF TERMS (MAP VERSION)

Coal — A compact, light weight dark brown to glossy black rock that is composed of vegetable material physically and chemically altered to a concentrated fixed carbon product.

Coking coal — A form of coal, usually of bituminous rank, where the coal material softens and flows when heated to just below the

point of ignition. During this process, volatile gasses escape and leave the dull-gray porous mass that is called coke.

Syncline — A rock structure that is formed from the large-scale folding of massive rock formations. The syncline is the 'U' shape of the downward folded portion of the rock.

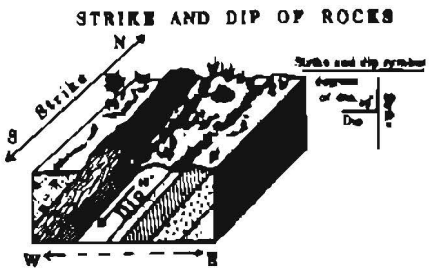
Dip of rocks — The angle from horizontal in which a rock unit lies.

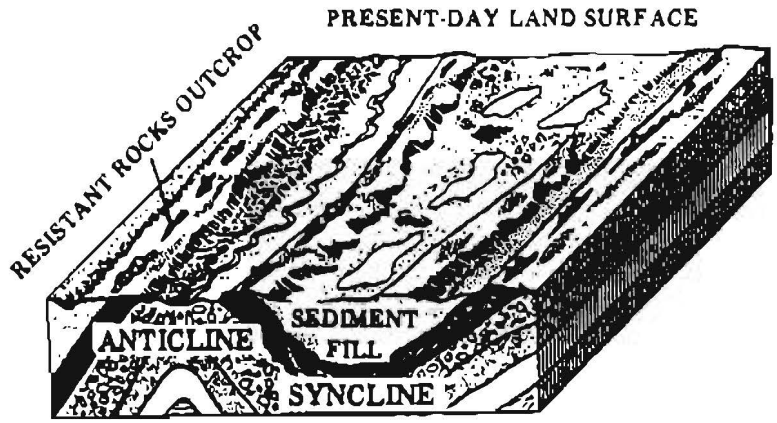
The dip of a rock unit can be the product of one or more deforming agencies, such as uplift, mountain building, fault movements or down-warping of rocks due to the weight of overlying sediments.

Strike of rocks — The strike is always perpendicular to the dip. If a rock unit is dipping at some angle toward the north, the strike will be east-west.

Deformation — Deformation is any physical change in attitudinal position or volume of rocks from the original configuration that they had when formed. Folding, tilting and warping are forms of deformation. So are compression (squeezing) and tension (stretching).

Anticline — A rock structure that is formed from the large-scale folding of massive rock formations. The anticline is the " _ " shape of the upward folded portion of the rock. Illustration:





FOLDED ROCKS

Btu — British thermal unit. One British thermal unit is the equivalent of the same amount of heat it takes to heat one pound of water one degree fahrenheit. This is the standard unit of heat used in describing the heating value of most fuels.

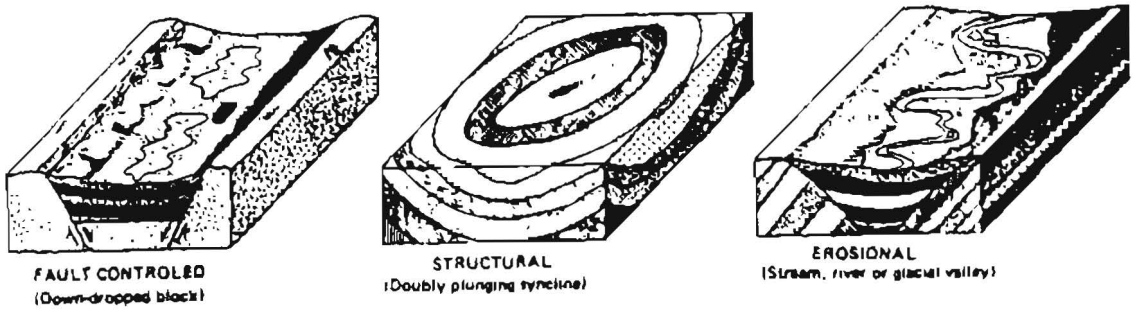
Bone coal — A coal that contains a high percentage of impurities such as clay, dirt, or rock fragments.

Ash — The residual mineral matter impurities left after the combustion of coal.

Coal float — Fragment of coal that have been displaced from the parent coal bed. This can occur through normal erosion. Coal fragments found in stream gravels, in rock and gravel talus at the base of a bluff, in landslide material and in other places removed from the in-place coal bed - are all called coal float.

Basin — Any structural depression in the earth's surface. Structural basins are where thick accumulations of sediments collect. Many such basins provide an environment whereby the thick layers of vegetable matter that may become coal can accumulate. Ancient basins that served as coal-forming environments may have undergone uplift and erosion through geologic time. In this case, what was at one time a basin may now be incorporated in a present-day topographically high area, such as a hill or mountain. Nevertheless, if it' original configuration was that of a basin, it will be described as such in geologic terms. Illustration:

SOME TYPES OF BASINS



Coal rubble — Similar to coal float, but often the fragments of a fractured sub-surface coal bed being 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 exposure. Coal rubble is usually found close to the parent coal bed.

Coal resources — Naturally occurring concentrations or deposits of coal in the earth's crust, in such forms and amounts that economic extraction is currently or potentially feasible.

Coal reserves — Identified, recoverable coal resources.

sub-categories
1. measured reserves...accessed and virgin coal reserves having the highest degree of geologic assurance
2. indicated reserves...categories of virgin reserves having a moderate degree of geologic assurance.
3. inferred reserves...categories of virgin coal reserves having a low degree of geologic assurance.

Mississippian — The lower ½ of the geologic period called the carboniferous. The carboniferous period was a time when many of the world's coal deposits formed. It spans the time from 360 million years ago to 185 million years ago. The Mississippian subdivision spans the time from 360 million years ago to 320 million years ago, a total of 40 million years.

Cretaceous — The geologic period spanning the time from 140 million years ago to 65 million years ago. Many of Alaska's coals were formed during the Cretaceous period.

Tertiary — The geologic period spanning the time from 65 million years ago to 1.5 million years ago. Many of Alaska;s coals are Tertiary in age.

Quaternary — The geologic period spanning the time from the end of the Tertiary through the present, or the last 1.5 million years.

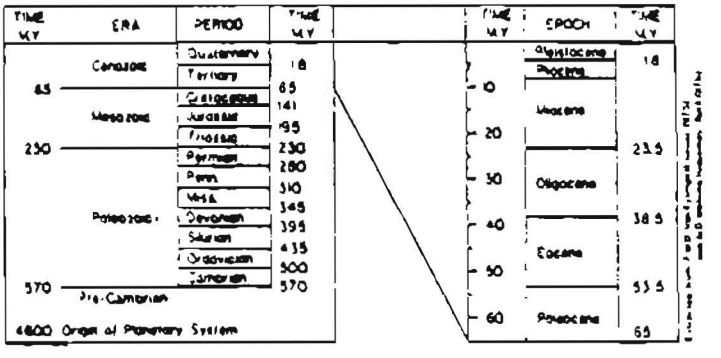


Figure 1. Geologic time scale.

Taken from: 'Coal Resource Classification System of the U.S. Geological Survey', by Gordon H. Wood, Jr., Thomas M. Kehn, M. Devereux Carter, and William C. Culbertson, U.S. Geological Survey Circular 891

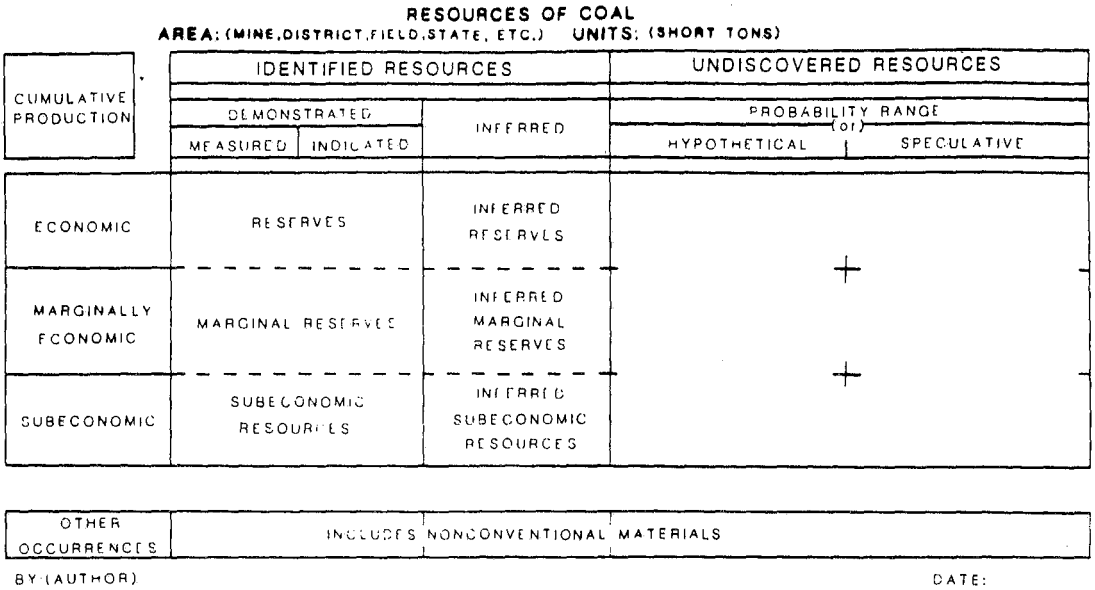


FIGURE 1.—Format and classification of coal resources by reserves and subeconomic resources categories.

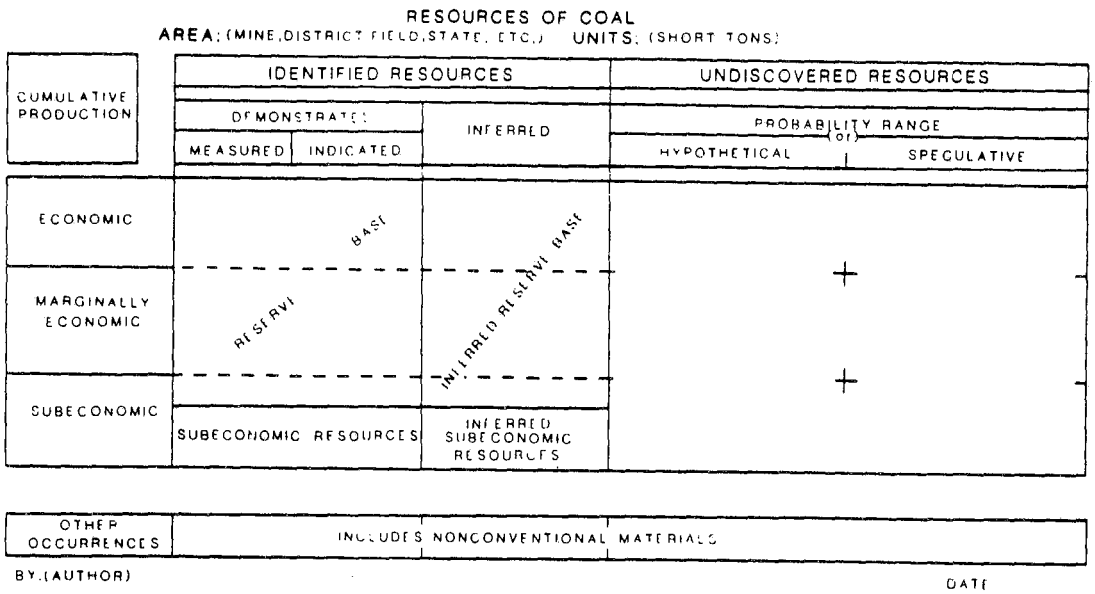


FIGURE 2.—Format and classification of coal resources by reserve and inferred reserve bases and subeconomic and inferred subeconomic resources categories

GLOSSARY OF COAL CLASSIFICATION SYSTEM AND SUPPLEMENTARY TERMS

Some of the following general definitions of coal resources and supplementary terms are amplified elsewhere in this report by criteria and guidelines for usage. The criteria and guidelines may be revised periodically to reflect changing national needs without affecting the definitions.

All definitions herein refer only to usage in this coal resources classification system and are not intended as definitions of the terms relative to any other usage.

Comparative values for units in the metric and English (U.S. Customary) systems of measurement are based on the Handbook of Chemistry and Physics by R. C. Weast (1971, p. F-242-F-263).

Note.—Glossary terms and specific criteria are cross-referenced within this report. To aid the reader, glossary items, beginning below, are printed in **boldface** type, and specific criteria, beginning on p. 24, are printed in ***boldface italics***.

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accessed.—Coal deposits that have been prepared for mining by construction of portals, shafts, slopes, drifts, and haulage ways; by removal of overburden; or by partial mining. See **virgin coal**.

acre.—A measure of area in the United States: 43,560 square feet; 4,840 square yards; 4,046.856 square meters; 0.4046856 hectare; 0.0015625 square mile; 0.0040468 square kilometer.

acreage.—The number of acres at the ground surface

acre-foot (acre-ft).—The volume of coal that covers 1 acre at a thickness of 1 foot (43,560 cubic feet; 1,613.333 cubic yards; 1,233.482 cubic meters). The weight of coal in this volume varies according to **rank**.

acre-inch (acre-in.).—The volume of coal that covers 1 acre at a thickness of 1 inch (3,630 cubic feet; 134.44 cubic yards; 102.7903 cubic meters). The weight of coal in this volume varies according to **rank**.

agglomerating.—Coal that, during volatile matter determinations, produces either an agglomerate button capable of supporting a 500-gram weight without pulverizing, or a button showing swelling or cell structure.

anthracite or **anthracitic.**—A rank class of nonagglomerating coals as defined by the American Society for Testing and Materials having more than 86 percent fixed carbon and less than 14 percent volatile matter on a dry, mineral-matter-free basis. (*Anthracite* is preferred usage). This class of coal is divisible into the semianthracite, anthracite, and meta-anthracite groups on the basis of increasing fixed carbon and decreasing volatile matter. (See table 1.)

ash.—The inorganic residue remaining after complete incineration of coal.

ash content.—The percentage of a laboratory sample of coal remaining after incineration to a constant weight under standard conditions following D-2795-69 (ASTM, 1981, p. 335-342).

ash free.—A theoretical analysis calculated from basic analytical data expressed as if the total ash had been removed.

as-received condition or **as-received basis.**—Represents an analysis of a sample as received at a laboratory.

assess.—To analyze critically and judge definitively the geologic nature or economic potential, significance, status, quality, quantity, potential usability, and other aspects of coal resources and reserves.

assessment.—A critical analysis based on integrating, synthesizing, evaluating, and interpreting all available data aimed at a judgment of the geologic nature or economic potential of the coal resources and reserves of an area, field, district, basin, region, province, county, state, nation, continent, or the world. An *assessment* differs from an estimate, which is a determination of the amount of coal in an area. An estimate or estimates may be the principal data used to assess the coal resources and reserves of an area. See **economic assessment** and **geologic assessment**.

auger mining.—A method often associated with contour strip mining to recover additional coal after the overburden to coal ratio has become too great for further contour mining. Coal is produced by boring into the coal bed much like a carpenter's wood bit bores into wood. An auger consists of a cutting head and screw-like extensions.

bed.—All the coal and partings lying between a roof and floor. The terms "seam" and "vein" should not be used.

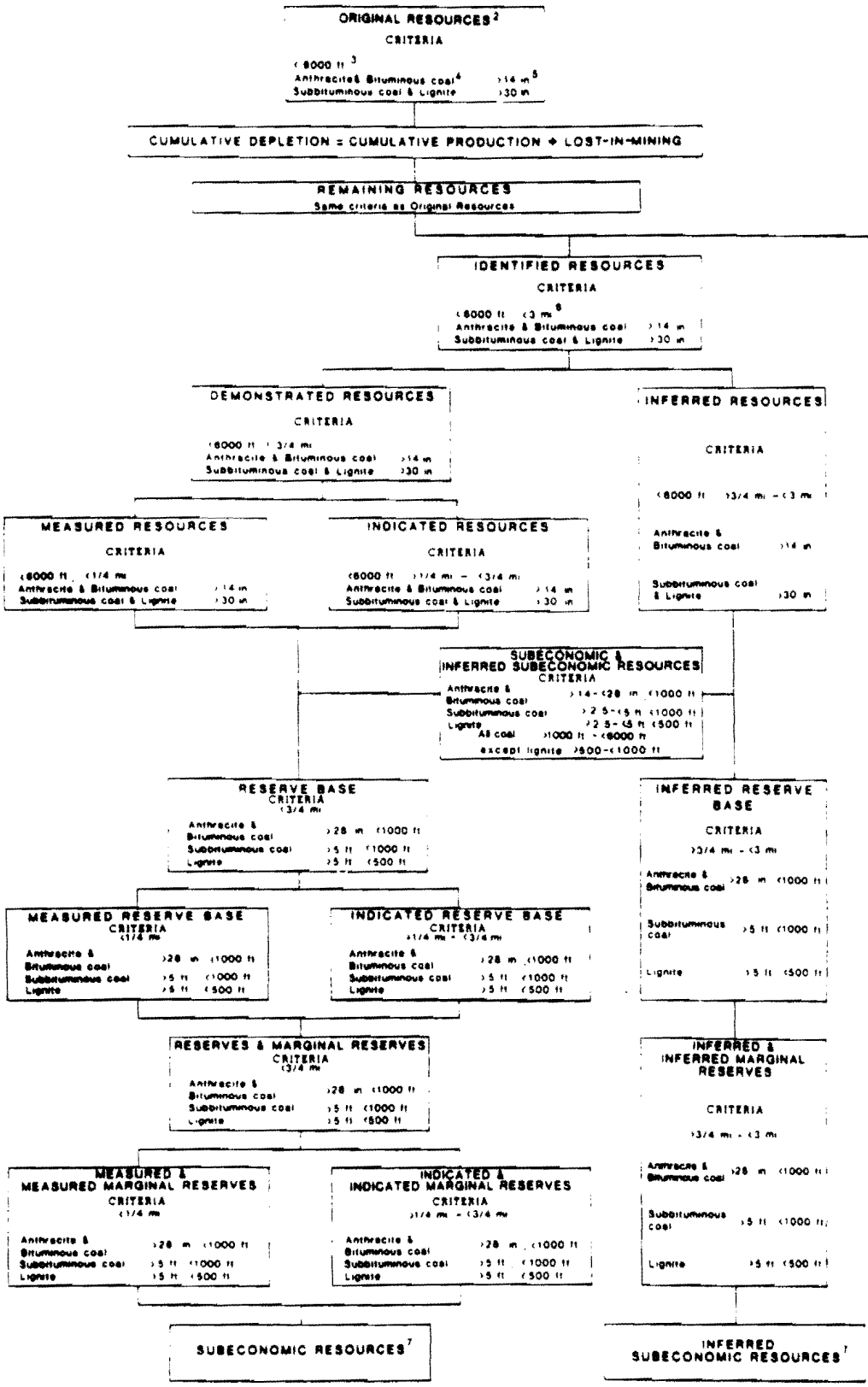
bench.—A subdivision and (or) layer of a coal bed separated from other layers by partings of non-coal rock.

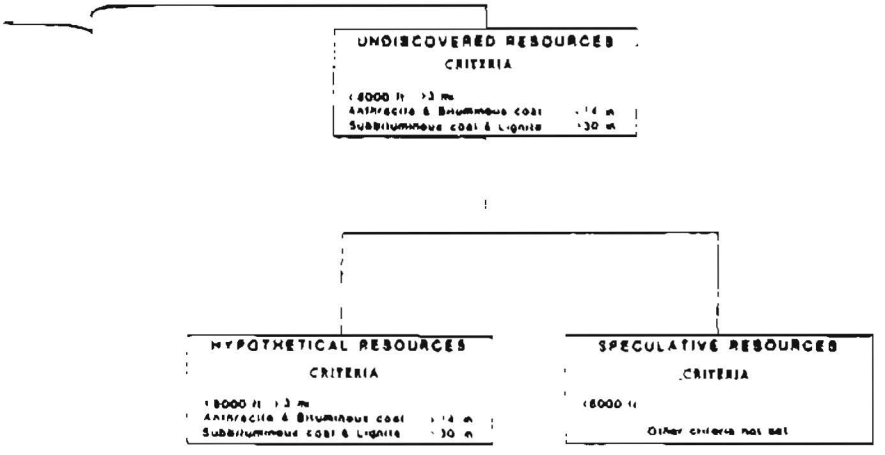
bituminous coal.—A rank class of coals as defined by the American Society for Testing and Materials (ASTM) high in carbonaceous matter, having less than 86 percent fixed carbon, and more than 14 percent volatile matter on a dry, mineral-matter-free basis and more than 10,500 Btu on a moist, mineral-matter-free basis. This class may be either agglomerating or nonagglomerating and is divisible into the high-volatile C, B, A; medium; and low-volatile bituminous coal groups on the basis of increasing heat content and fixed carbon and decreasing volatile matter. (See table 1.)

bone coal or **bone.**—Impure coal that contains much clay or other fine-grained detrital mineral matter (ASTM, 1981, D-2796, p. 344). See **impure coal**.

Discussion: The term *bone coal* has been erroneously used for cannel coal, canneloid coal, and well-cemented to metamorphosed coaly mudstone and (or) claystone. *Bone coal* has also been applied to carbonaceous partings. The term "impure coal" accompanied by adjective modifiers such as "silty,"

HIERARCHY OF COAL RESOURCES[1]





1 Coal resource terms are defined in glossary

2 Resources before mining

3 500 ft, 1000 ft, and 6000 ft Depth of burial or overburden thickness

4 Anthracite, bituminous, subbituminous, and lignite are ranks of coal See Table 1

5 14 in , 28 in 30 in and 5 ft are minimum thicknesses of coal.

6 1/4 mi, 3/4 mi, and 3 mi are distances from points of measurement of coal thickness.

7 Includes coal left in room and pillar mining, in property barriers, coal too thick to be recovered completely by conventional mining, and mine and preparation plant waste.

NOTE

OTHER OCCURRENCES

Includes coal

a) less than minimum thickness at any depth

b) containing more than 33 weight percent ash on dry basis

c) buried at depths of more than 6 000 feet

Estimated tonnage where calculated, is to be reported as "Other Occurrences" and not as resources, unless mined. Where mined, tonnage quantity is included in reserve base and reserve estimates.

criteria for distinguishing resource categories.

"shaly," or "sandy," is the preferred usage because the definition of *bone coal* does not specify the type or weight percentages of impurities.

British thermal unit (Btu).—The quantity of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit (°F) at, or near, its point of maximum density of 39.1° F (equivalent to 251.995 gram calories; 1,054.35 Joules; 1.05435 kilojoules; 0.25199 kilocalorie).

burn line.—The contact between burned and unburned coal in the subsurface. In the absence of definitive information, the subsurface position of a *burn line* is assumed to be vertically below the surface contact between unaltered and altered rocks. See **clinker**.

calorie (cal).—The quantity of heat required to raise 1 gram of water from 15° to 16° Celsius. A calorie is also termed gram calorie or small calorie (equivalent to 0.00396832 Btu; 4.184 Joules; 0.001 kilogram calorie).

clinker.—Baked or fused rock formed from the heat of a burning underlying coal bed.

coal.—A readily combustible rock containing more than 50 percent by weight and more than 70 percent by volume of carbonaceous material, including inherent moisture. It is formed from plant remains that have been compacted, indurated, chemically altered, and metamorphosed by heat and pressure during geologic time.

Discussion: Differences in the kinds of plant materials, in the degree of metamorphism (rank), and in the range of impurities are characteristic of *coal* and are used in coal classification. Impure coal/coaly material containing more than 33 weight percent ash is excluded from resources and reserve estimates unless the ash is largely in associated partings so that the *coal* is cleanable to less than 33 weight percent ash.

coal bed.—See **bed**.

coal field.—A discrete area underlain by strata containing one or more coal beds. (See figs. 5 and 6.)

coal measures.—Strata containing one or more coal beds.

coal province.—An area containing two or more coal regions. (See fig. 8.)

coal region.—An area containing one or more coal fields. (See fig. 7.)

coal reserves.—See **reserves**. (See also *reserves*, p. 30.)

coal zone.—A series of laterally extensive and (or) lenticular coal beds and associated strata that arbitrarily can be viewed as a unit. Generally, the coal beds in a *coal zone* are assigned to the same geologic member or formation.

coke.—A gray, hard, porous, and coherent cellular-structured solid, primarily composed of amorphous carbon. *Coke* is combustible and is produced by destructive distillation or thermal decomposition of certain bituminous coal that passes through a plastic state in the absence of air.

concentration.—A greater than normal accumulation of substances such as (1) coal, (2) elements, (3) compounds, and (4) minerals. In coal resource terminology, *concentration* is used in two senses: (1) concentrations of coaly material into beds that are minable, and (2) concentrations of elements, compounds, and minerals that may add or detract from the value of the extracted coal. A *concentration* of a substance always exceeds the average content of that substance in the Earth's crust.

consolidated coal.—See **lignite**.

content.—The amount of ash, an element, an oxide, other types of compounds, or a mineral in a unit amount of coal, expressed in parts per million or percent. Also refers to the heat value of coal as expressed in Joules per kilogram (J/kg), kilojoules per kilogram (kJ/kg), British thermal units per pound (Btu/lb), or calories per gram (cal/g).

control point.—A **point of measurement**, a **point of observation**, or a sampling point.

correlate, correlation.—Demonstration of the apparent continuity of a coal bed between control, measurement, or sampling points by showing correspondence in character and stratigraphic position.

Discussion: Correlations of coal beds are based on a knowledge of the stratigraphy of the coal beds and of the enclosing rocks and of the unique characteristics of individual coal beds. Confidence in correlations increases as the knowledge and abundance of data increases. Where a coal bed is continuously exposed along an outcrop or strip-mine face, continuity of the coal bed becomes an established fact and not a *correlation*.

Where data indicate that correlation of a coal bed is possible or probable among data points within an area, an estimate of the resources of that coal bed can be made for the entire area. However, where a coal bed at single data point cannot be correlated with beds at other data points, or where there is only one data point, resources can be calculated for that coal bed using the single data point as the center of circles defining measured, indicated, and inferred.

cumulative depletion.—The sum in tons of coal extracted and lost-in-mining to a stated date for a

specified area or a specified coal bed. (See *cumulative depletion*, p. 25; and fig. 3.)

cumulative production.—The sum in tons of coal extracted to a stated date for a specified area or a specified coal bed. (See *cumulative production*, p. 25; and figs. 1, 2, and 3.)

demonstrated.—A term commonly used for the sum of coal classified as measured and indicated resources. Used when not feasible or desirable to subdivide into **measured** and **indicated**. (See figs. 1, 2, and 3.)

demonstrated reserves.—Same as **reserves**. (See also, *demonstrated reserves*, p. 25; and figs. 1, 2, and 3.)

demonstrated reserve base.—Same as **reserve base**. (See also *demonstrated reserve base*, p. 25, and figs. 1, 2, and 3.)

demonstrated resources.—See **resources**. (See also, *demonstrated resources*, p. 25; and figs. 1, 2, and 3.)

density.—Mass of coal per unit volume. Generally expressed in short tons/acre-foot or metric tons/hectare/square hectometer-meter of coal. See **specific gravity**.

depleted resources.—Resources that have been mined; includes coal recovered, coal lost-in-mining, and coal reclassified as subeconomic because of mining. See **cumulative depletion**. (See also *cumulative depletion*, p. 25; and fig. 3.)

depth (overburden) categories.—Coal tonnage data are divided into classes by the thickness of overburden: 0–500 feet (0–150 m); 500–1,000 feet (150–300 m); 1,000–2,000 feet (300–600 m); 2,000–3,000 feet (600–900 m); and 3,000–6,000 feet (900–1,800 m). See **overburden**.

Discussion: The depth categories or overburden categories (see table 3, and specific instruction No. 2, p. 33) were decided after consultation among personnel from the U.S. Geological Survey, the Bureau of Mines, and various State Geological Surveys, mining companies, and agencies of foreign nations.

dry, mineral-matter-free basis.—A type of calculated analytical value of a coal sample expressed as if the total moisture and mineral matter had been removed. *Mineral-matter-free* is not the same as **ash-free**.

economic.—This term implies that profitable extraction or production under defined investment assumptions has been established, analytically demonstrated, or assumed with reasonable certainty.

economic assessment.—A critical analysis resulting in a judgment of the economic nature, significance, status, quantity, quality, market, demand, supply, costs, transportation, cash flow, capital, and processing of the coal resources of a mine, area, district, field, basin, region, province, county, state, or nation. See **assessment**.

estimate.—A determination as to the amount or tonnage of coal in an area. The term *estimate* indicates that the quantities of resources are known imprecisely. An *estimate* differs from an assessment, which is an analysis of all data concerning an area's coal resources and reserves with the objective of reaching a judgment about the geologic nature and economic potential of the coal resources and reserves of the area.

existing market conditions.—The relations between production, selling and transportation costs, supply, demand, and profit at any time.

extraction.—The process of removing coal from a deposit.

feasibility.—The possibility of extracting coal.

fixed carbon.—The solid residue, other than ash, obtained by destructive distillation of a coal, determined by definite prescribed methods (ASTM, 1981, p. 183).

floor.—Stratigraphically, the rock immediately underlying a coal bed. Where the bed is overturned, the stratigraphic *floor* is the mining roof.

gasification, underground (in situ).—A method of utilizing coal by burning in place and extracting the released gases, tars, and heat. See **in situ mining**.

geologic assessment.—A critical analysis resulting in a judgment of the geologic nature, significance, status, quality, and quantity of the coal resources of an area, district, basin, region, township, quadrangle, province, county, state or political province, nation, continent, or the world. See **assessment** and **economic assessment**.

geologic assurance.—State of sureness, confidence, or certainty of the existence of a quantity of resources based on the distance from points where coal is measured or sampled and on the abundance and quality of geologic data as related to thickness of overburden, rank, quality, thickness of coal, areal extent, geologic history, structure, and correlations of coal beds and enclosing rocks. The degree of assurance increases as the nearness to points of control, abundance, and quality of geologic data increases.

geologic evidence.—Information derived from geologic observations that can be used to substantiate the existence, size, depth, attitude, structure, tonnage, and physical and chemical characteristics of a body of coal.

geologic identification.—State of being identified as to location, areal extent or size, depth, volume, quantity, magnitude, and quality of coal resources.

grade.—A term indicating the nature of coal as mainly determined by the sulfur content and the amount and type of ash. This term is not recommended for usage in coal resource estimations; definitive statements as to the contents and types of sulfur and ash are preferable. Statements indicating high, medium, or low grade are inappropriate without documentation. See **quality**

heat value or **heat of combustion.**—The amount of heat obtainable from coal expressed in British thermal units per pound, joules per kilogram, kilojoules or kilocalories per kilogram, or calories per gram. To convert Btu/lb to kcal/kg, divide by 1.8. To convert kcal/kg to Btu/lb, multiply by 1.8.

hectare (ha) or **square hectometer** (hm^2).—A metric unit of area equal to 10,000 square meters; 0.010 square kilometer; 2.4710538 acres; 107,639.10 square feet; 11,959.9 square yards; 0.003861 square mile.

high-ash coal.—Coal containing more than 15 percent total ash on an as-received basis. See **ash-content**, **medium-ash coal**, and **low-ash coal**.

high-sulfur coal.—Coal containing 3 percent or more total sulfur on an as-received basis. See **low-sulfur coal** and **medium-sulfur coal**.

high-volatile bituminous coal.—Three related rank groups of bituminous coal as defined by the American Society for Testing and Materials which collectively contain less than 69 percent fixed carbon on a dry, mineral-matter-free basis; more than 31 percent volatile matter on a dry, mineral-matter-free basis; and a heat value of more than 10,500 Btu per pound on a moist, mineral-matter-free basis. (See table 1.)

hypothetical.—A low degree of geologic assurance. Estimates of rank, thickness, and extent are based on assuming continuity beyond inferred. Estimates are made, not exceeding a specified depth beyond coal classed as inferred, by projection of thickness, sample, and geologic data from distant outcrops, trenches, workings, and drill holes. There are no measurement sites in areas of hypothetical coal. Used as a modifier to resource terms. See **resources** and **undiscovered**. (See also figs. 1, 2, and 3.)

hypothetical resources.—See Undiscovered Resources, p. 20; (See also ***hypothetical resources***, p. 25; and figs. 1, 2, and 3.)

identified resources.—See Identified Resources, p. 19; (See also ***identified resources***, p. 25; and figs. 1, 2, and 3.)

impure coal.—Coal having 25 weight percent or more, but less than 50 weight percent ash on the dry basis (ASTM, 1981, D-2796, p. 344). *Impure coal* having more than 33 weight percent ash is excluded from resource and reserve estimates unless the coal is cleanable to less than 33 weight percent ash. See **bone coal**.

indicated.—A moderate-degree of geologic assurance. Estimates of quantity, rank, thickness, and extent are computed by projection of thickness, sample, and geologic data from nearby outcrops, trenches, workings, and drill holes for a specified distance and depth beyond coal classed as measured. The assurance, although lower than for measured, is high enough to assume continuity between points of measurement. There are no sample and measurement sites in areas of indicated coal. However, a single measurement can be used to classify coal lying beyond measured as *indicated* and to assign such coal to resource and reserve base categories (fig. 4). Used as a modifier to resource terms.

indicated reserves and **indicated marginal reserves.**—See **reserves** and **indicated**. (See also ***indicated reserves*** and ***indicated marginal reserves***, p. 25; and figs. 1, 2, and 3.)

indicated reserves base and **indicated marginal reserve base.**—See **reserve base**. (See also ***indicated reserve base***, p. 26; and figs. 1, 2, and 3.)

indicated resources.—See Indicated Resources, p. 19. (See also ***indicated resources***, p. 26; and figs. 1, 2, and 3.)

inferred.—A low-degree of geologic assurance. Estimates of quantity, rank, thickness, and extent are based on inferred continuity beyond measured and indicated for which there is geologic evidence. Estimates are computed by projection of thickness, sample, and geologic data from distant outcrops, trenches, workings, and drill holes for a specified distance and depth beyond coal classed as indicated. There are no sample and measurement sites in areas of inferred coal. However, a single measurement can be used to classify coal lying beyond indicated as *inferred* and to assign such coal to inferred resource and inferred reserve base categories (fig. 4). Used as a modifier to resource terms.

inferred reserves and **inferred marginal reserves.**—See subdivisions of **reserves**. (See also ***inferred reserves***, p. 26, and ***inferred marginal reserves***, p. 26; and figs. 1, 2, and 3.)

inferred reserve base.—See **reserve base**. (See also ***inferred reserve base***, p. 26; and figs. 1, 2, and 3.)

inferred resources.—See Inferred Resources, p. 19. (See also ***inferred resources***, p. 26; and figs. 1, 2, and 3.)

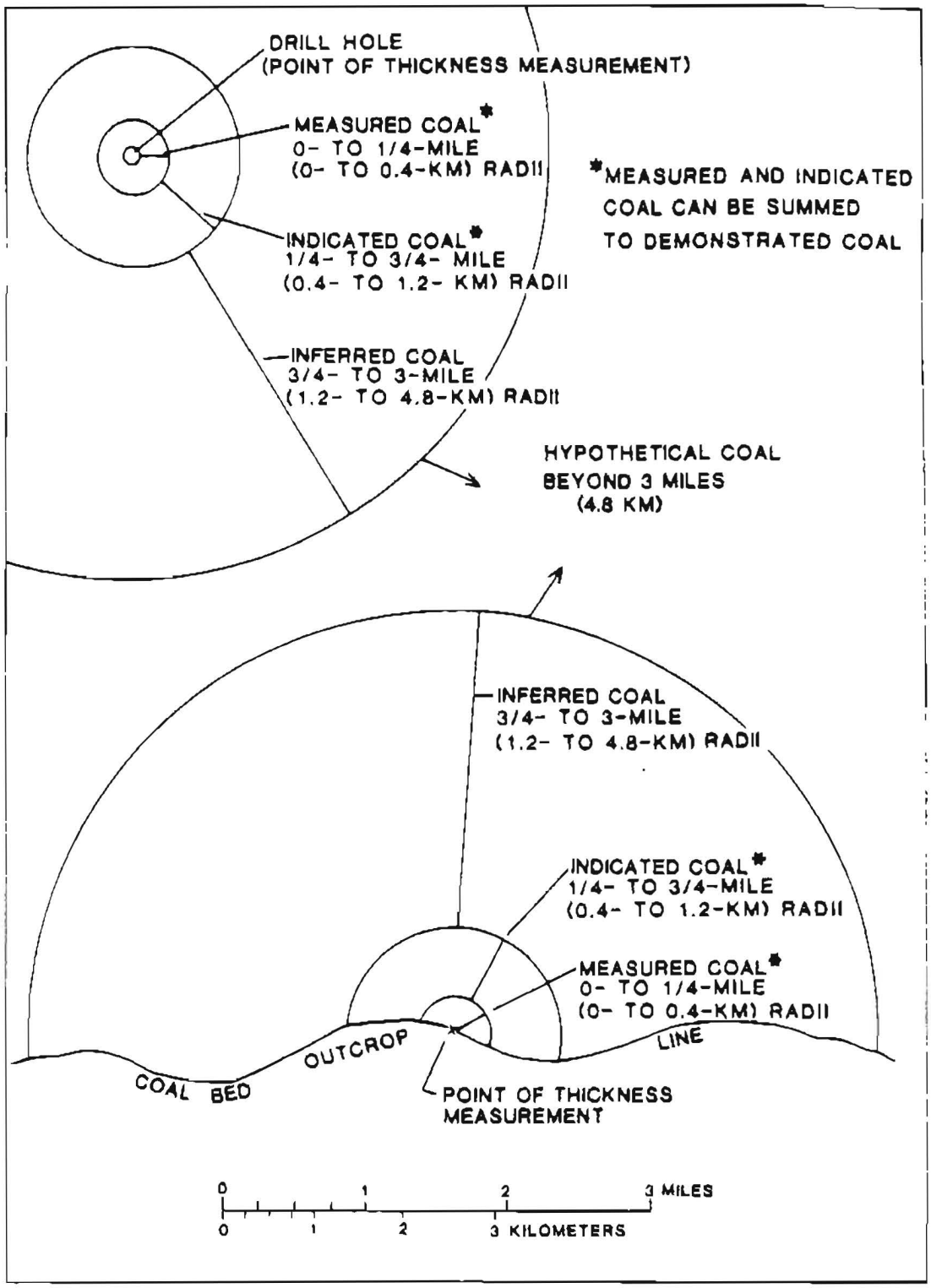


FIGURE 4 —Diagram showing reliability categories based solely on distance from points of measurement.

inferred subeconomic resources.—See Inferred Subeconomic Resources, p. 20. (See also *inferred subeconomic resources*, p. 31; and figs. 1, 2, and 3.)

in situ.—Refers to coal "in place" in the ground.

in situ mining.—Utilization of coal by burning in place and extracting the gases, tars, and heat.

joule (J).—The basic metric unit of work or energy equal to 1×10^7 ergs, 0.238662 gram calorie, 0.0002386 kilogram-calorie, or 0.0009471 Btu.

kilogram-calorie (kcal).—A metric unit of heat equal to 1,000 gram-calories; 3.9683207 Btu; 4,184 Joules; 4.184×10^{10} ergs; or 4,184 Watt seconds. Also known as "large calorie."

kilogram (kg).—The basic metric unit of weight measurement equal to 1,000 grams; 0.001 metric ton; 2.2046 pounds, 0.0011023 short ton; 0.0009842 long ton.

kilojoule (kJ).—A metric unit of work or energy equal to 1,000 joules; 0.948708 Btu; or 238.662 gram-calories.

known coal.—Coal whose existence has been perceived from measurements and observations at the outcrop, in mines, from drill holes, and from exploratory trenches. Data confirming existence may be projected for several miles (kilometers) if based upon reasonable geologic assumptions. See **identified resources**. Coal fields, basins, regions, provinces, and occurrences of coal in the United States are illustrated in figures 5, 6, 7, and 8.

lignite or lignitic.—A class of brownish-black, low-rank coal defined by the American Society for Testing and Materials as having less than 8,300 Btu on a moist, mineral-matter-free basis. (See table 1.) In the United States, *lignite* is separated into two groups: Lignite A (6,300 to 8,300 Btu) and lignite B ($< 6,300$ Btu). *Lignite* is the preferred usage.

long ton.—A unit of weight in the U.S. Customary System and in the United Kingdom equal to 2,240 pounds (1.0160469 metric tons; 1.1200 short tons; 1,016.0469 kilograms). This term is not recommended for use in estimates of coal resources.

lost-in-mining.—Coal remaining in the ground after all extraction is completed. *Lost-in-mining* includes coal that is (1) left to support mine roofs, (2) too thin to mine, (3) unmined around oil, gas, water, and disposal wells, (4) unmined around shafts and electrical and water conduits, (5) unmined as barrier pillars adjacent to mine or property boundaries, (6) unmined adjacent to haulageways, tunnels, airways, and waterways, (7) unmined because of many other unspecified reasons, (8) the unrecovered or unrecoverable part of any coal bed in a mining property that has been or may be extracted, (9) all unrecoverable in beds that closely overlie a mined bed, (10) all unrecoverable in beds that closely underlie a mined bed, (11) unmined between mining properties.

Discussion: According to this system of classification, *lost-in-mining* equals reserve base minus reserves and marginal reserves. Thus, *lost-in-mining* includes all reserve base coal not economically recoverable at the time of classification or not bordering on being economically recoverable. Lost-in-mining coal is subtracted from the reserve base and is divisible into subeconomic coal or noneconomic coal according to its potential for being reclassified as economic. (See fig. 3.)

low-ash coal.—Coal containing less than 8 percent total ash on an as-received basis. See **ash content**, **high-ash coal**, and **medium-ash coal**.

low-sulfur coal.—Coal containing 1 percent or less total sulfur on an as-received basis. See **high-sulfur coal** and **medium-sulfur coal**.

low-volatile bituminous coal.—A rank group of bituminous coal as defined by the American Society for Testing and Materials containing more than 78 percent and less than 86 percent fixed carbon, and more than 14 percent and less than 22 percent volatile matter on a dry, mineral-matter-free basis. (See table 1.)

marginal reserves.—Borders on being economic. See **economic**; general guideline no. 8, p. 32; and subdivisions of **reserves**. (See also *indicated marginal reserves* and *measured marginal reserves*, p. 25 and 27; and figs. 1, 2, and 3.)

measured.—The highest-degree of geologic assurance. Estimates of quantity are computed partly from dimensions revealed in outcrops, trenches, workings, and drill holes and partly by projection of thickness, sample, and geologic data not exceeding a specified distance and depth. Rank is calculated from the results of detailed sampling that may be located at some distance from this type of resource and may be on the same or other coal beds. The sites for thickness measurement are so closely spaced and the geologic character so well defined that the average thickness, areal extent, size, shape, and depth of coal beds are well established. However, a single measurement can be used to classify nearby coal as *measured* (fig. 4). Used as a modifier to resource terms.

measured reserves and **measured marginal reserves.**—See subdivisions of **reserves**. (See also *measured reserves*, p. 27; *measured marginal reserves*, p. 27; and figs. 1, 2, and 3.)

measured reserve base.—See **reserve base**. (See also *measured reserve base*, p. 27; and figs. 2 and 3.)

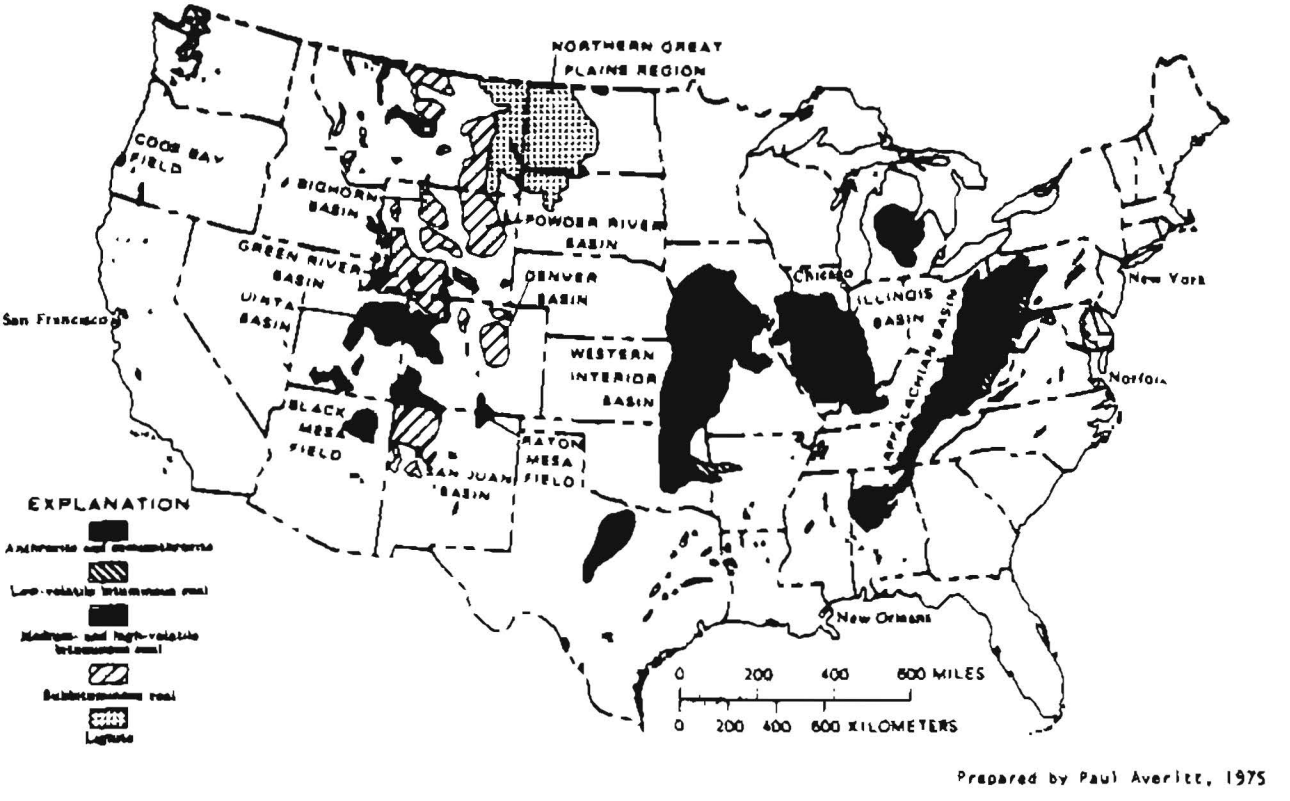


FIGURE 5.—Coal fields of the conterminous United States (from Averitt, 1975).

measured resources.—See Measured Resources, p. 19; (See also ***measured resources***, p. 27; and figs. 1, 2, and 3.)

medium-ash coal.—Coal containing 8 percent to 15 percent ash on an as-received basis. See **ash content**, **low-ash coal**, and **high-ash coal**.

medium-sulfur coal.—Coal containing more than 1 percent and less than 3 percent total sulfur on an as-received basis. See **high-sulfur coal** and **low-sulfur coal**.

medium-volatile bituminous coal.—A rank group of bituminous coal as defined by the American Society for Testing and Materials containing more than 69 percent and less than 78 percent fixed carbon and more than 22 percent and less than 31 percent volatile matter on a dry, mineral-matter-free basis. (See table 1.)

metallurgical coal.—An informally recognized name for bituminous coal that is suitable for making coke by industries that refine, smelt, and work with iron. Other uses are space heating, blacksmithing, smelting of base metals, and power generation. Generally, *metallurgical coal* has less than 1 percent sulfur and less than 8 percent ash on an as-received basis. Most premium *metallurgical coal* is low- to medium-volatile bituminous coal.

metric ton, megagram, tonne, or millier.—A metric unit of weight equal to 1,000 kilograms; 1.1023113 short tons; 0.98420653 long ton; 2,204.6226 pounds. The *metric ton* is the preferred usage.

minable.—Capable of being mined under current mining technology and environmental and legal restrictions, rules, and regulations.

mineral-matter.—The solid inorganic material in coal.

mineral-matter-free basis.—A theoretical analysis calculated from basic analytical data expressed as if the total mineral-matter had been removed. Used in determining the rank of a coal.

mining.—All methods of obtaining coal or its byproducts from the Earth's crust, including underground, surface, and in situ mining.

moist, mineral-matter-free basis.—A theoretical analysis calculated from basic analytical data and expressed as if the mineral-matter had been removed and the natural moisture retained. Used in determining the rank of coal.

moisture, bed.—The percentage of moisture or water in a bed or sample of coal before mining.

moisture content.—The percentage of moisture (water) in coal. Two types of moisture are found in

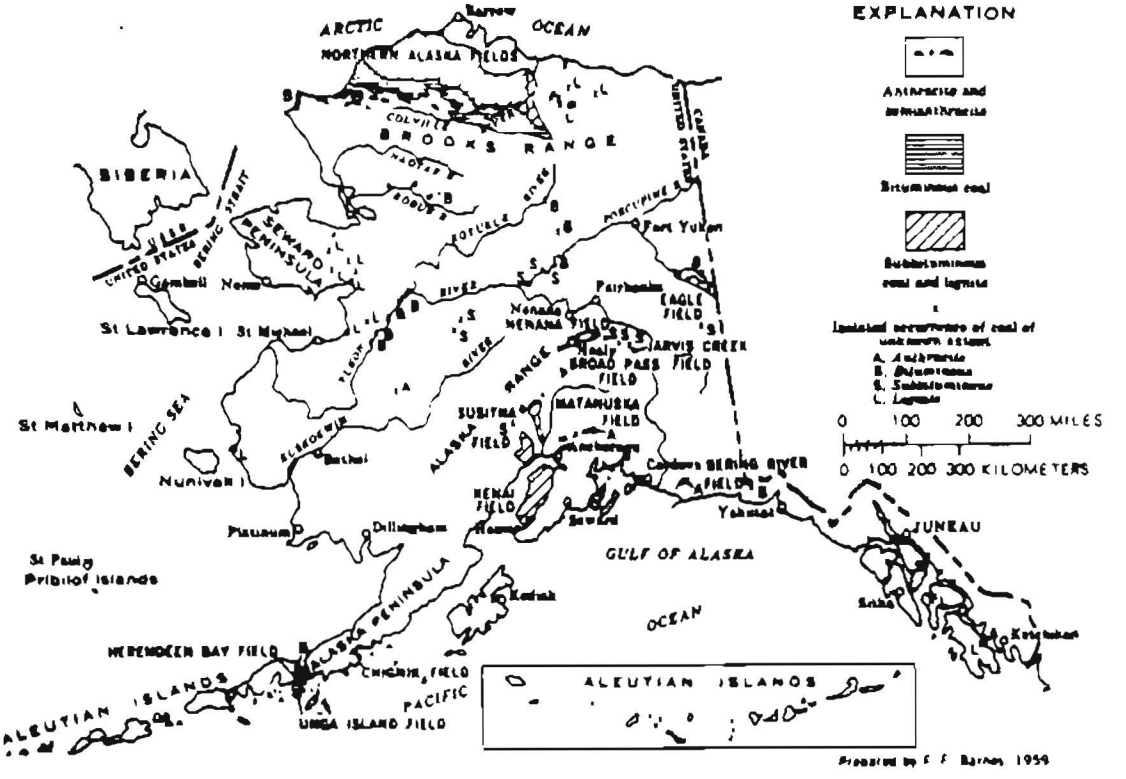


FIGURE 6 —Coal fields of Alaska (from Averitt, 1975).

coal, namely, free or surface moisture removed by exposure to air, and inherent moisture entrapped in the coal and removed by heating to 220°F.

noneconomic.—Not capable of profitable production or extraction. Coal classified as *noneconomic* may be reported in other occurrences. See ***other occurrences, nonconomic coal***, p. 27.

original.—The amount of coal resources in the ground before production.

original resources.—See Original Resources, p. 19; and **original resources.** (See also *original resources*, p. 27; and figs. 1, 2, and 3.)

other occurrences.—Coal in the ground that is excluded from classification as coal resources. Includes anthracite and bituminous coal less than 14 inches thick, subbituminous coal and lignite less than 30 inches thick, and any coal more than 6,000 feet deep unless it is currently being mined. May include coal that contains more than 33 percent ash. (See ***other occurrences, noneconomic coal***, p. 27; and figs. 1 and 2.)

overburden.—Rock including coal and (or) unconsolidated material that overlies a specified coal bed. *Overburden* is reported in feet and (or) meters and used to classify the depth to an underlying coal bed.

partial or incomplete measurement of coal thickness.—A determination of an incomplete coal thickness at a point of measurement.

Discussion: Measurements of coal thicknesses that are incomplete because of (1) near surface slumping of coal and overlying beds, (2) weathering, (3) a drill hole not penetrating the entire coal bed, (4) identified planar erosion of top part of coal bed, or (5) removal of most of a coal bed by a stream channel are to be treated as points of measurement from which circles of reliability are to be constructed. A geologist must decide whether each measurement is complete or incomplete. The thickness of coal at places where a measurement is deemed incomplete shall be located on the coal bed map by the number of feet and inches actually measured followed by a plus sign to indicate that only a part of the bed was measured. Thus, incomplete measurements define measured coal of a stated minimum thickness. If other thickness data are available to show by isopaching that a coal thickness is incomplete at a point of measurement, the isopached total thickness at the point of measurement should be used to determine the average thickness for the tonnage

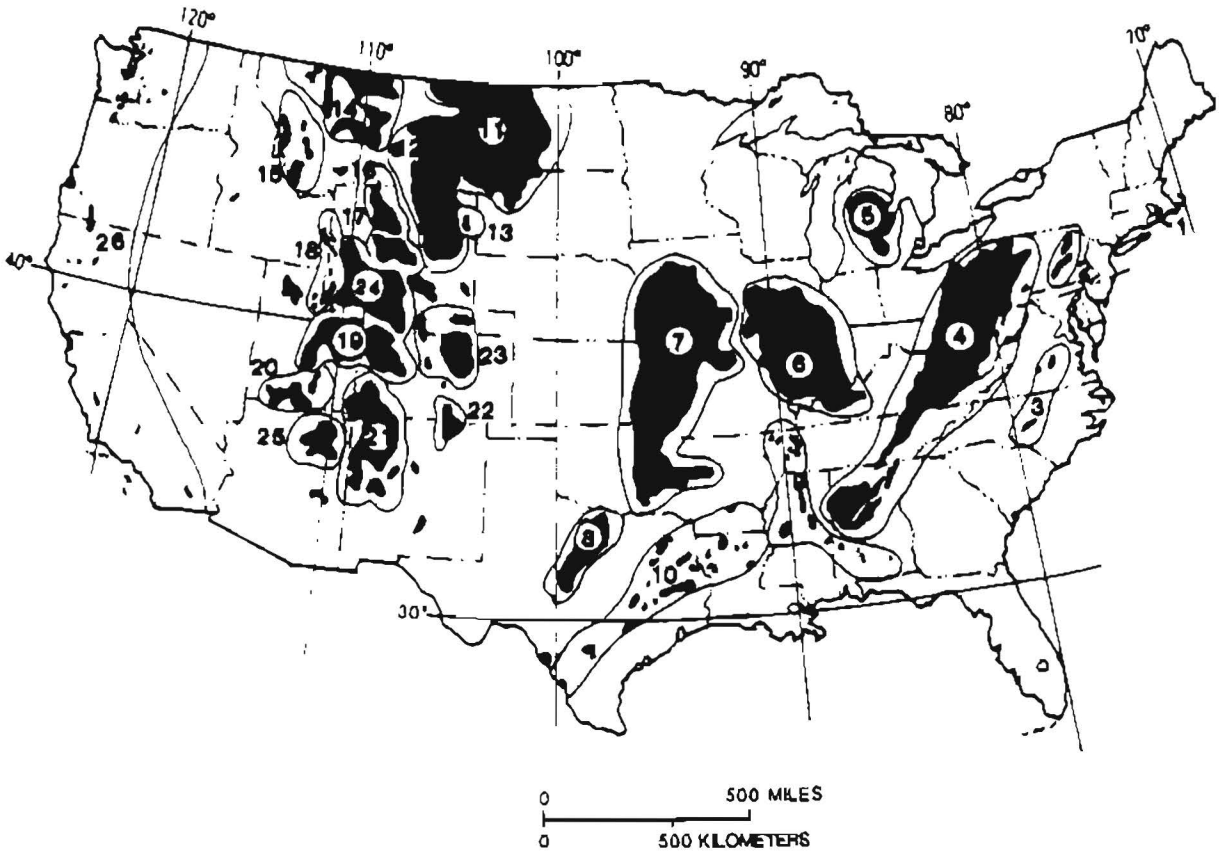


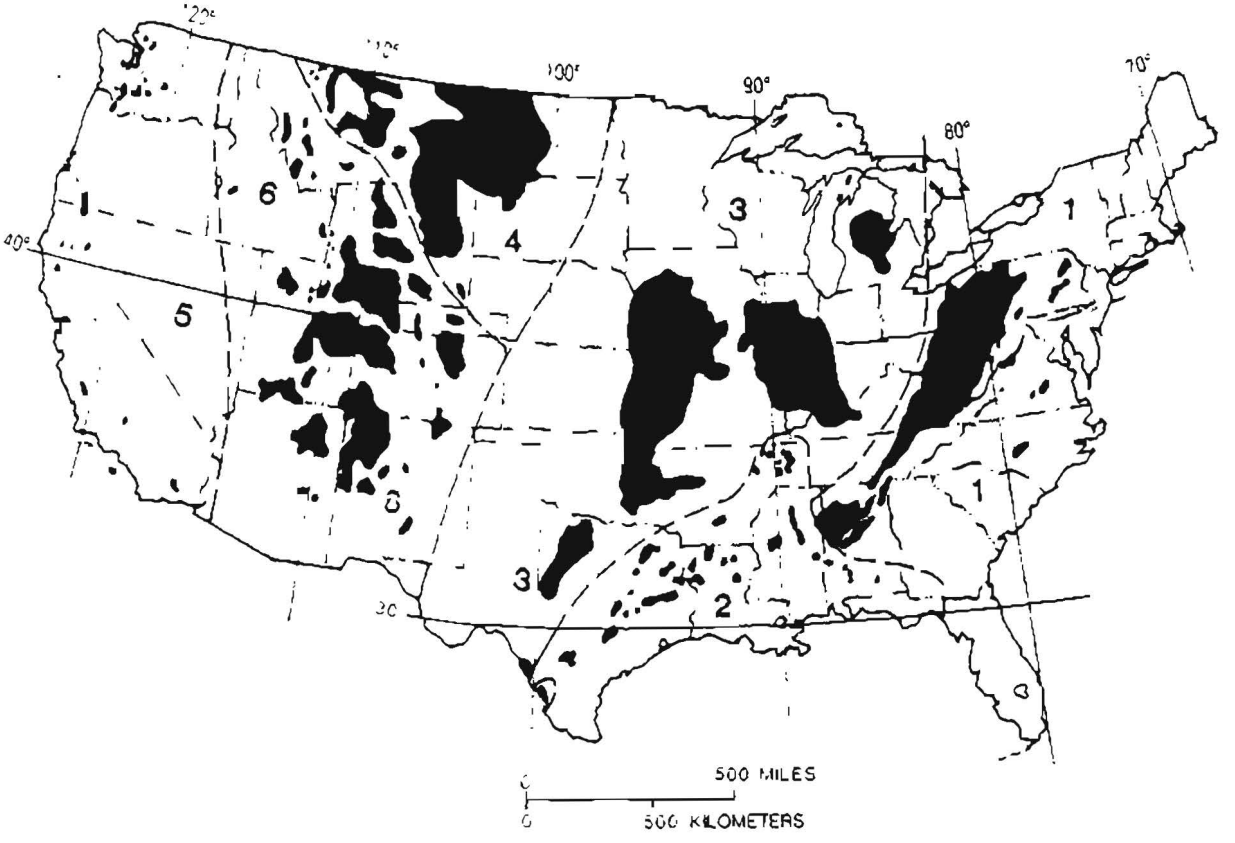
FIGURE 7.—Coal regions of the conterminous United States (modified from Trumbull, 1960.)

estimates of measured, indicated, and inferred categories. In those places where the coal bed cannot be isopached, the partial thickness of coal should be used as the thickness for estimating tonnages. See **point of measurement**.

parting.—A layer or stratum of non-coal material in a coal bed which does not exceed the thickness of coal in either the directly underlying or overlying benches. (See specific instruction No. 3, p. 34.)

parts per million (ppm).—A method of stating content of a substance in coal. One *ppm* equals 0.001 percent, or 0.000001.

point of measurement.—The exact location on an outcrop, in a trench, in mine workings, or in a drill hole



EXPLANATION

1 Eastern
2 Gulf
3 Interior
4 Northern Great Plains
5 Pacific Coast
6 Rocky Mountains

FIGURE 8.—Coal provinces of the conterminous United States (modified from Trumbull, 1960).

where a coal bed is measured for thickness and (or) sampled for analysis. The surface position of a *point of measurement* must be located precisely on a map so that its geodetic position can be determined. The altitude of a subsurface *point of measurement* can be determined from cores, lithologic logs, mine workings, and also can be determined from a geophysical log of a drill hole or well if, in the opinion of a geologist or geophysist, the log is of good quality. See **partial or incomplete measurement of coal thickness**

point of observation.—Place on an outcrop where a coal bed is visible or where evidence indicates that a coal bed could be measured or examined by trenching or digging a pit. Points of observation are used to verify the existence of a coal bed, and apparent similarity and (or) difference of a coal bed's thickness as to thickness at points of measurement. They also can be used to confirm the position of a coal outcrop on a geologic map and to support the measured, indicated, and inferred classification of a coal bed; however, these points cannot be used without actual measurements to classify a resource body.

production.—The coal that has been extracted from a mine for a specified period. *Production* may be reported for a mine or larger area such as a coal field, region, province, basin, township, quadrangle, state, nation, and (or) the world. Production in the United States is usually reported in short tons; most other nations report production in metric tons.

proximate analysis.—In coal, the determination by

TABLE 1.—*Classification of coals by rank*[A]

Class	Group	Fixed Carbon Limits, percent (Dry, Mineral-Matter-Free Basis)		Volatile Matter Limits, percent Dry, Mineral-Matter-Free Basis		Calorific Value Limits BTU per pound (Moist,[B] Mineral-Matter-Free Basis)		Agglomerating Character
		Equal or Greater Than	Less Than	Greater Than	Equal or Less Than	Equal or Greater Than	Less	
I. Anthracite[D]	1. Meta-anthracite	98	----	----	2	----	----	nonagglomerating
	2. Anthracite	92	98	2	8	----	----	
	3 Semianthracite[C]	86	92	8	14	----	----	
II Bituminous	1. Low volatile bituminous coal	78	86	14	22	----	----	commonly agglomerating[E]
	2. Medium volatile bituminous coal	69	78	22	31	----	----	
	3 High volatile *A* bituminous coal	----	69	31	----	14 000[D]	----	
	4 High volatile *B* bituminous coal	----	----	----	----	13 000[D]	14 000	
	5 High volatile *C* bituminous coal	----	----	----	----	11 500	13 000	
		----	----	----	----	10 500	11 500	agglomerating
III. Subbituminous	1 Subbituminous *A* coal	----	----	----	----	10 500	11 500	nonagglomerating
	2. Subbituminous *B* coal	----	----	----	----	9 500	10 500	
	3 Subbituminous *C* coal	----	----	----	----	8 300	9 500	
IV Lignite	1 Lignite *A*	----	----	----	----	6 300	8 300	
	2 Lignite *B*	----	----	----	----	----	6 300	

[A]This classification does not include a few coals, principally nonbanded varieties, which have unusual physical and chemical properties and which come within the limits of fixed carbon or calorific value of the high-volatile bituminous and subbituminous ranks. All of these coals either contain less than 48 percent dry, mineral-matter-free fixed carbon or have more than 15 500 moist, mineral-matter-free British thermal units per pound.

[B]Moist refers to coal containing its natural inherent moisture but not including visible water on the surface of the coal.

[C]If agglomerating, classify in low-volatile group of the bituminous class.

[D]Coals having 69 percent or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of calorific value.

[E]It is recognized that there may be nonagglomerating varieties in these groups of the bituminous class, and there are notable exceptions in the high-volatile *C* bituminous group.

[F]ASTM, 1981, p. 215.

[G]Modified from ASTM, 1981.

prescribed methods of moisture, volatile matter, fixed carbon (by difference), and ash. Unless specified, proximate analyses do not include determinations of sulfur or phosphorous or any determinations other than those named. Proximate analyses are reported by percent and on as-received, moisture-free, and moisture- and ash-free bases.

quality.—An informal classification of coal relating to its suitability for use for a particular purpose.

Discussion: Most coal is used as a source of heat or energy, but coal is or will be used in making petrochemicals, metallurgical coke, synthetic gas, and synthetic liquid fuel. Factors considered in judging a coal's quality are based on, but not limited to, heat value; content of moisture, ash, fixed carbon, phosphate, silica, sulfur, major, minor and trace elements; coking and petrologic properties; and organic constituents considered both individually and in groups. The individual importance of these factors varies according to the intended use of the coal. Therefore, any designation of "high-quality coal," "moderate-quality coal," or "low-quality coal" should plainly indicate the intended or optimum use or uses and is inappropriate without such documentation.

quantity.—Refers to the amount or tonnage of coal. *Quantity* should be reported in short or metric tons.

rank.—The classification of coals according to their degree of metamorphism, progressive alteration, or coalification (maturation) in the natural series from lignite to anthracite.

Discussion: Classification is made on the basis of analysis of coal in accordance with table 1. The *rank* of coal can be used to infer the approximate dry,

mineral-matter-free heat value, fixed carbon, and volatile matter in a coal, because the amounts of the constituents vary little within each coal rank. (See table 1; and ***rank calculation***, p. 28.)

rank calculation.—The determination of the rank of a coal. Such determination must use the instructions given under ***rank calculation***, p. 28.

recoverable coal.—The coal that is or can be extracted from a coal bed during mining. The term "recoverable" should be used in combination with "resources" and not with "reserves."

recovery percent.—The percentage of coal extracted from a bed where the total tonnage originally in the bed is equal to 100 percent.

recovery factor.—The estimated or actual percentage of coal that can be or was extracted from the coal originally in a bed or beds for an area, mine, district, field, basin, region, province, township, quadrangle, county, state, political province, nation, and (or) the world. See ***recovery factor method***, p. 28.

reliability categories.—Categories based on distance from points of measurement and (or) sampling. The measured, indicated, inferred, and hypothetical resource categories, as defined, indicate the relative reliability of tonnage estimates as related to distance from points of thickness control of particular parts of a coal deposit. The ***reliability categories*** are not indicative of the reliability of the basic data (that is, the accuracy of coal measurements, or the accuracy of location of the coal outcrop). It is assumed that all basic data used in resource estimation have been judged reliable by the estimator and that unreliable data have been discarded. (See fig. 4.)

reserves.—Virgin and (or) accessed parts of a coal reserve base which could be economically extracted or produced at the time of determination considering environmental, legal, and technologic constraints. The term ***reserves*** need not signify that extraction facilities are in place or operative. ***Reserves*** include only recoverable coal; thus, terms such as "extractable reserves" and "recoverable reserves" are redundant and are not a part of this classification system. (See figs. 1 and 3; and ***reserves***, p. 30.)

Discussion: ***Reserves*** can be categorized as measured and indicated, as underground or surface minable, by thickness of overburden, by thickness of coal in the bed, and by various quality factors. The term "economic reserves" is not to be used because ***reserves*** by definition are economic. ***Reserves***, which are derived from reserve base coal, exclude coal thinner or deeper than that classified as reserve base unless such coal is currently mined. See general guideline No. 7, p. 32.

MANDATORY SUBDIVISIONS:

A. Indicated Reserves and Indicated Marginal Reserves.—Categories of virgin reserves having a moderate degree of geologic assurance. See **indicated** and **marginal reserves**. (See also ***reserves***, p. 30; and figs. 1 and 3.)

B. Inferred Reserves and Inferred Marginal Reserves.—Categories of virgin reserves having a low degree of geologic assurance. See **inferred reserves** and **marginal reserves**. (See also ***reserves***; p. 30; and figs. 1 and 3.)

C. Measured Reserves and Measured Marginal Reserves.—Categories of accessed and virgin coal reserves having the highest degree of geologic assurance. See **measured reserves** and **marginal reserves**. (See also figs. 1 and 3.)

OPTIONAL SUBDIVISIONS:

A. Reserves and Marginal Reserves.—***Reserves*** may be divided into subcategories other than those heretofore defined. These subcategories may be differentiated, for example, by ash and sulfur content, and heat value; by types or varieties of coal such as boghead or cannel coal; by usage such as metallurgical, petrochemical, and synthetic fuel types; by mineral ownership such as State, Federal, Indian, or private ownership; by Federal coal underlying private surface ownership; and by reserves and restricted reserves underlying State or national parks, monuments, forests, grasslands; military and naval reservations, alluvial valley floors, steep slopes, lakes and large rivers, and environmentally protected areas.

1. Restricted Reserves and Restricted Marginal Reserves.—Those parts of any reserve category that are restricted or prohibited by laws or regulations from extraction by underground and (or) surface mining.

Discussion: For example, coal in a national park may meet all the physical, chemical and economic requirements of a reserve but is prohibited from extraction. The assignment to a restricted category may be either temporary or permanent; however, because laws and regulations can be repealed or changed, such coal should be separately distinguished, and tonnage estimates recorded as a restricted reserve. Locally, a specific regulation or law might prohibit one method of mining and allow or not specify other methods. In such a circumstance, the coal would be restricted

from mining by the prohibited method and tonnage estimates would be so recorded. In other circumstances, other methods would be unrestricted, and tonnage estimates would be reported accordingly.

The separation of coal reserves into the many different subcategories listed above and other subcategories not listed in this text is desirable and encouraged. All subcategories not listed should be defined clearly and explicitly so that other resource specialists and the public will not be confused.

reserve base.—Those parts of the identified resources that meet specified minimum physical and chemical criteria related to current mining and production practices, including those for quality, depth, thickness, rank, and distance from points of measurement. (See **reliability categories**; and figs. 2 and 3.) The *reserve base* is the in-place demonstrated (measured plus indicated) resource from which reserves are estimated. The *reserve base* may encompass those parts of a resource that have a reasonable potential for becoming economically available within planning horizons beyond those that assume proven technology and current economics. The *reserve base* includes those resources that are currently economic (reserves), marginally economic (marginal reserves), some of those that are currently subeconomic (subeconomic resources), and some of the resources that have been or will be lost-in-mining but whose attributes indicate possible future recovery. The term "geologic reserve" has been applied by others to the reserve base category, but it also may include the inferred reserve base category; it is not a part of this classification system. (See ***reserve base***, p. 29; and figs. 2 and 3.)

reserve base, inferred.—The in-place part of an identified resource from which inferred reserves and inferred marginal reserves are estimated. Quantitative estimates are based largely on knowledge of the geologic character of a coal deposit for which there are no samples or measurements. The estimates are based on an assumed continuity beyond the reserve base for which there is geologic evidence. (See figs. 2 and 3.)

resources.—Naturally occurring concentrations or deposits of coal in the Earth's crust, in such forms and amounts that economic extraction is currently or potentially feasible. (See ***resources***, p. 30; and figs. 1, 2, and 3.)

MANDATORY SUBDIVISIONS:

A. Hypothetical Resources.—See Undiscovered Resources (p. 20). (See also ***hypothetical resources***, p. 25; and figs. 1, 2, and 3.)

B. Identified Resources.—Resources whose location, rank, quality, and quantity are known or estimated from specific geologic evidence. (See ***identified resources***, p. 25). Identified coal resources include economic, marginally economic, and subeconomic components. To reflect varying distances from points of control or reliability, these subdivisions can be divided into demonstrated and inferred, or preferably into measured, indicated, and inferred. (See ***identified resources***, p. 25; and figs. 1, 2, and 3.)

Discussion: *Identified resources* may be accessed and (or) in bodies of virgin coal which are assigned to resource and reserve base subcategories on the basis of geologic evidence from maps, samples, drill holes, wells, mine records, and fieldwork. Specific evidence must include data on the location, thickness of overburden, distance from points of measurement or sampling, and extent and thicknesses of the resource bodies. Evidence about quality and rank may be determined from analyses of samples collected from the resource bodies or may be inferred by projection of analytical data obtained elsewhere in the body or from adjacent bodies. An identified resource body may contain reserves, marginal reserves, inferred reserves, inferred marginal reserves, reserve base, inferred reserve base, demonstrated resources, measured resources, indicated resources, inferred resources, subeconomic resources and inferred subeconomic resources. (See figs. 1, 2, and 3.)

C. Indicated Resources.—Identified bodies of virgin coal having a moderate degree of geologic assurance. See **indicated**. (See also ***indicated resources***, p. 26; and figs. 1, 2, and 3.)

D. Inferred Resources.—Identified bodies of virgin coal having a low degree of geologic assurance. See **inferred resources**. (See also ***inferred resources***, p. 26; and figs. 1, 2, and 3.)

E. Measured Resources.—Accessed and virgin demonstrated resources having a high degree of geologic assurance. (See ***measured resources***, p. 27; and figs. 1, 2, and 3.)

F. Original Resources.—The amount of coal in place before production. Where mining has occurred, the total of *original resources* is the sum of the identified resources, undiscovered resources, coal produced, and coal lost-in-mining. (See ***original resources***, p. 27; and figs. 1, 2, and 3.)

G. Remaining Resources.—The resources in the

ground in a mine, area, field, basin, region, province, county, state, and (or) nation after some mining. The term does not include coal lost-in-mining unless such coal can be considered potentially recoverable. *Remaining resources* may be divided into categories such as remaining economic, marginally economic, subeconomic, measured, indicated, inferred, identified, and undiscovered (hypothetical and speculative) resources or other types of resources. (See optional subdivisions, below; and figs. 1, 2, and 3.) The total remaining resources are the sum of the remaining identified and undiscovered resources as of the date of the estimate.

H. Subeconomic Resources.—That part of identified (demonstrated) resources that does not meet the economic criteria of reserves and marginal reserves. See **resources** and **economic**. (See also ***subeconomic resources***, p. 31; and figs. 1 and 2.)

I. Inferred Subeconomic Resources.—That part of identified (inferred) resources that does not meet the economic criteria of inferred reserves or inferred marginal reserves. See **resources** and **economic**. (See also ***subeconomic resources***, p. 31; and figs. 1 and 2.)

J. Speculative Resources.—See Undiscovered Resources (below). (See also ***speculative resources***, p. 30; and figs. 1, 2 and 3.)

K. Undiscovered Resources.—*Undiscovered resources*, the existence of which is only postulated, comprise deposits that are either separate from or are extensions of identified resources. *Undiscovered resources* may be postulated in deposits of such quality, rank, quantity, and physical location as to render them economic, marginally economic, or subeconomic. To reflect varying degrees of geologic certainty, *undiscovered resources* may be subdivided into two parts as follows. (See ***undiscovered resources***, p. 31.)

1. Hypothetical Resources.—A class of undiscovered resources that are either similar to known coal deposits which may be reasonably expected to exist in the same coal field or region under analagous geologic conditions or are an extension from inferred resources. In general, *hypothetical resources* are in the central parts of broad areas of coal fields where points of sampling and measurement and evidence for thickness and existence is from distant outcrops, mine workings, drill holes, and wells. If exploration confirms the existence of hypothetical resources and reveals enough information about their quality, quantity, and rank, they will be reclassified as identified resources.

2. Speculative Resources.—A class of undiscovered resources that may occur either in known types of deposits in favorable geologic settings where coal deposits have not been discovered or in types of deposits as yet unrecognized for their economic potential. If exploration confirms the existence of speculative resources and reveals enough information about their quality, quantity, and rank, they will be reclassified as identified resources.

OPTIONAL SUBDIVISONS:

Resources may be divided into subcategories, for example, on the basis of ash content, sulfur content, and heat value; type or variety of coal such as boghead or cannel coal; usage such as metallurgical, petrochemical, and synthetic fuel types; resources underlying specified lands owned by State governments, the Federal Government, or private interests; by restricted resources underlying State or national parks, monuments, forests, grasslands; military, naval, and Indian reservations; and alluvial valley floors, steep slopes, lakes and large rivers, and environmentally protected areas.

A. Restricted Resources.—Those parts of any resource category that are restricted or prohibited from extraction by laws or regulations.

Discussion: Restricted resources meet all requirements of coal classified as resources, except that they are restricted from extraction by law or regulation. The assignment to a restricted category may be either temporary or permanent, but, because laws and regulations can be repealed or changed, such coal should be separately distinguished and tonnage estimates recorded as restricted resources.

The division of coal resources into the many different categories described heretofore and into other categories not differentiated in the text is desirable and encouraged. Many requests for information about resources are received by coal resource specialists and are unanswerable because the scopes of the systems of classification used in the past were too limited. Persons and institutions classifying resources are, therefore, encouraged to use initiative in defining and developing additional classes of coal resources.

restricted reserves.—See optional subdivisions of **reserves**.

restricted resources.—See optional subdivisions of **resources**.

roof.—Stratigraphically, in underground mining the rock immediately overlying a coal bed. Where a bed is overturned, the stratigraphic *roof* is the mining floor.

sample.—A representative fraction of a coal bed collected by approved methods, guarded against contamination or adulteration, and analyzed to determine the nature; chemical, mineralogic, and (or) petrographic composition; percentage or ppm content of specified constituents; heat value; and possibly the reactivity of the coal or its constituents.

Discussion: Some samples are also collected so that fossil remains can be ascertained and physical, magnetic, or other geophysical properties can be determined, tested, observed, or analyzed. All samples should be accompanied by a description of the *sample*, including location, thickness of coal, and stratigraphic relationship to other rocks.

TYPES OF SAMPLES:

A. **as-received sample.**—A sample of coal as it is received at a laboratory.

B. **bed or channel sample.**—A sample of coal collected from a channel cut perpendicular to the stratification.

Discussion: This type of sample is used to ascertain the chemistry, rank of coal, mineralogy, petrography, and geophysical and physical properties of coal. Instructions for this type of sampling are contained in Geological Survey Circular 735 (Swanson and Huffman, 1976, p. 2).

C. **bench sample.**—A sample of a subdivision and (or) layer of a coal bed separated from other subdivisions by partings of non-coal rock.

Discussion: The term *bench sample* does not apply to coal lithotypes such as vitrinite and exinite as used by petrologists.

D. **blend pile sample.**—A sample of coal collected from the blend-pile of a processing plant or a utilization facility such as a powerplant or steel mill.

E. **breaker sample.**—A sample of coal broken or crushed in a breaker plant. A *breaker sample* is usually collected prior to cleaning of coal.

F. **cleaned coal sample.**—A sample of coal collected after use of a cleaning procedure.

G. **core sample.**—A sample of coal recovered from a core which was obtained at depth by a coring device in a drill hole.

H. **cutting sample.**—A sample of coal taken from the cuttings returned during drilling.

Discussion: Cutting samples are not recommended because many comparisons with properly or conventionally collected samples indicate they are rarely representative.

I. **delivered coal sample.**—A sample of coal collected from a shipment that is being or will be delivered to a user.

J. **grab sample.**—A sample, commonly a single piece, selected from a coal bed, tipple, preparation plant, blend pile, conveyor belt, or coal car.

Discussion: Grab samples are not recommended because many comparisons with properly collected samples indicate they are rarely representative.

K. **mine sample.**—A sample of coal collected from a mine, generally from an underground working face or from a strip-wall face.

L. **run of mine** or **mine run sample.**—Generally the same as a **tipple sample**.

M. **tipple sample.**—A sample of coal collected at a mine tipple.

seam.—A bed of coal lying between a roof and floor. This term is not to be used in place of "coal bed" in reports of the U.S. Geological Survey.

short ton.—A unit of weight equal to 2,000 pounds; 0.9071847 metric ton, tonne, or megagram; 0.8928571 long ton.

specific gravity of coal.—The ratio of the mass of a unit volume of coal to the mass of an equal volume of water at 4°C.

Discussion: The *specific gravity of coal* varies considerably with rank and with differences in ash content. The values shown in table 2 are close to the average specific gravities of unbroken or unmined coal in the ground (in situ) for the four major rank categories and are to be used in preparing U.S. Geological Survey estimates of coal resources and reserves.

Persons associated with individual mining operations sometimes use lower specific gravity factors to allow for anticipated losses in extraction. Such usage may be suitable for specific mine areas but is not recommended for use in general reports because the recoverability of coal varies greatly between areas, beds, mining methods, and mine operators.

speculative.—Lowest degree of geologic assurance. Estimates of rank, thickness, and extent are based on

TABLE 2.—*Average specific gravity and average weight of unbroken coal per unit volume of different ranks*

Rank	Specific gravity	Weight of unbroken coal per unit volume						
		Short tons per acre-foot	Short tons per acre-inch	Metric tons per acre foot	Short tons per square mile-foot	Metric tons per square mile-foot	Metric tons per square hectometer-meter	Metric tons per square hectometer meter
Anthracite and semianthracite	1.47	2,000	166.6	1,814	1,280,000	1,160,960	14,700	1,470,000
Bituminous coal	1.32	1,800	150	1,633	1,152,000	1,045,120	13,200	1,320,000
Subbituminous coal	1.30	1,770	147.5	1,605	1,132,800	1,027,200	13,000	1,300,000
Lignite	1.29	1,750	145.8	1,588	1,120,000	1,016,320	12,900	1,290,000

assuming the existence of known types of coal deposits in favorable geologic settings or on assuming the existence of unknown types of deposits as yet unrecognized for their economic potentials. Tonnages are estimated by assuming thickness of coal, overburden, extent, and rank to a specified depth. There are geologic evidence sites but no measurement sites in areas of speculative coal. Used as a modifier to resource terms. See Hypothetical Resources, p. 20; Speculative Resources, p. 20; and Undiscovered Resources, p. 20. (See also figs. 1, 2, and 3.)

speculative resources.—See Speculative Resources, p. 20. (See also ***speculative resources***, p. 30; and figs. 1, 2, and 3.)

square hectometer-meter (hm²-m).—A metric unit of the volume of coal that covers 1 square hectometer at a thickness of 1 meter; 10,000 cubic meters; 10 cubic dekameters; 0.010 square kilometer-meter; 13,079.51 cubic yards; 8.107132 acre-feet; 0.0126674 square mile-foot. The weight of coal in this volume varies according to rank. (See table 1.)

square kilometer.—1,000,000 square meters; 100 hectares; 247.10538 acres; 1,195,990 square yards; 10,763,910 square feet.

square kilometer-meter (km²-m).—The volume of coal (1,000,000 cubic meters; 100 square hectare-meter-meters or 100 hectare-meters; 1,307,950.6 cubic yards; 35,314,667.0 cubic feet) that covers 1 square kilometer at a thickness of 1 meter. The weight of coal varies according to the rank. (See table 2.)

square mile.—27,878,400 square feet; 3,097,600 square yards; 2,589,988.1 square meters; 258.99881 hectares; 640 acres; 2.5899881 square kilometers.

square mile-foot.—The volume of coal (27,878,400 cubic feet; 789,428.38 cubic meters; 1,032,533.33 cubic yards) that covers 1 square mile to a thickness of 1 foot. The weight of coal varies according to the rank. (See table 2.)

strip or stripping ratio.—The amount of overburden that must be removed to gain access to a unit amount of coal.

Discussion: A *stripping ratio* may be expressed as (1) thickness of overburden to thickness of coal, (2) volume of overburden to volume coal, (3) weight of overburden to weight of coal, or (4) cubic yards of overburden to tons of coal. A *stripping ratio* commonly is used to express the maximum thickness, volume, or weight of overburden that can be profitably removed to obtain a unit amount of coal.

strip or surface mining.—The extraction of coal by using surface mining methods such as area strip mining, contour strip mining, or open-pit mining. The overburden covering the coal is removed and the coal extracted using power shovels, front end loaders, or similar heavy equipment.

subbituminous coal.—A rank class of nonagglomerating coals having a heat value content of more than 8,300 Btu's and less than 11,500 Btu's on a moist, mineral-matter-free basis. This class of coal is divisible on the basis of increasing heat value into the subbituminous C, B, and A coal groups. (See table 1.)

subeconomic resources.—See **resources** and **economic**. (See also ***subeconomic resources***, p. 31; and figs. 1, 2, and 3.)

sulfur content.—The quantity of sulfur in coal expressed in percent or parts per million. May be divided into the quantities occurring as inorganic (pyritic) sulfur, organic sulfur, and sulfate sulfur.

thickness categories.—The categories of thickness of coal beds employed in calculating, estimating, and reporting coal resources and reserves. (See ***thickness of coal for resource calculations***, p. 31; and specific instruction No. 3, p. 34.)

ultimate analysis.—In coal, the determination by prescribed methods of the ash, carbon, hydrogen, nitrogen, oxygen (by difference), and sulfur contents. Quantities of each analyzed substance are reported by percentage for the following conditions: as-received, dried at 105°C, and moisture-and ash-free.

Discussion: The principal reason for the *ultimate analysis* is the classification of coals by rank, although it

is often used for commercial and industrial purposes when it is desirable to know the sulfur content. The *ultimate analysis* also is known as the "total analysis." This, however, is a misnomer because substances other than those noted above are not identified and quantified, such as trace elements, oxides, and rare gases.

underground mining.—The extraction of coal or its products from between enclosing rock strata by underground mining methods, such as room and pillar, longwall, and shortwall, or through in situ gasification.

undiscovered.—A category of virgin resources of coal having the lowest degree of geologic assurance. Category is divisible into the hypothetical and speculative categories. (See **hypothetical** and **speculative.**) Estimates are quantitative. There are no sample or measurement of coal thickness sites in areas of undiscovered coal. Used as a modifier to resources.

undiscovered resources.—See mandatory subdivisions of **resources**. (See also ***undiscovered resources***, p. 31; and figs. 1, 2, and 3.)

vein.—A bed of coal lying between a distinct roof and floor. Term is not to be used in place of "coal bed" in reports of the U.S. Geological Survey.

virgin coal.—Coal that has not been accessed by mining. See **accessed**.

volatile matter.—In coal, those products, exclusive of moisture, given off as gas and vapor, determined by definite prescribed methods (ASTM, 1981, p. 184, D2361-66, D3761-79, D3175-77, D3176-74, D3178–73, and D3179–73).

CRITERIA FOR COAL RESOURCE CLASSIFICATION

Although not specifically noted, coal resources are classified in figures 1, 2, and 3 according to geologic assurances of existence and to the economic feasibility of recovery.

The degree of geologic assurance in this system of coal classification is determined from the interrelations of (1) proximity to or closeness of spacing of points where a coal bed is measured or sampled (reliability); (2) concepts, ideas, and models of the depth, rank, quality, thickness of coal, areal extent, depositional patterns and correlations of coal beds and enclosing rocks; and (3) knowledge of associated structural features as they control the distribution, extent, thickness, depth of burial, and metamorphism of coal resources. An understanding of these elements as they relate to the three dimensional configurations of stratigraphic sequence is necessary to provide the highest degree of geologic assurance as to the existence and continuity or lack of continuity of specific coal beds.

The degree of economic feasibility is determined by interrelating the (1) thickness of coal (see specific instruction No. 3, p. 34); (2) thickness of overburden; (3) the rank and quality of coal as ascertained from analyses that may be from the same bed or adjacent beds and which may be projected on geologic evidence for several miles; (4) costs of mining, processing, labor, transportation, selling, interest, taxes, and demand and supply; (5) expected selling price; and (6) expected profits.

The thickness of overburden and the thickness of a coal bed are the primary factors controlling the feasibility of mining. Knowledge of the quantity of coal and rock that must be removed per unit of recovered coal, of the roof and floor conditions, and of the difficulty of separating coal from rock determine the mining method and the equipment chosen for the mining operation. The rank, purity, heat value, and selling price of the coal commonly dictate usage and marketability. Higher rank coals generally are judged more valuable than lower rank coals owing to greater heat values and chemical characteristics that are sought currently by the metallurgical and petrochemical industries. Economic variables that influence feasibility are price of coal, cost of equipment, mining, labor, processing, transportation, interest rates, and taxes. Supply and demand for coal also influence feasibility as do environmental laws, restrictions, judicial rulings, and political considerations. The relative value of coals may change markedly in the near future as the result of utilizing new techniques for converting coal to gas and or liquid fuels. Low-rank coals and coals containing pyrite that are currently of lower economic value may in the future be considered premium fuels for conversion processes.

The criteria for the principal classes of coal resources described hereafter are summarized in table 3 and are to be used in preparing all U.S. Geological Survey coal resource estimates from January 1, 1983, until further revised.

APPLICATIONS OF CRITERIA

The criteria are to be applied only to those deposits of coal that are currently or potentially feasible for economic extraction by underground mining, surface mining, and (or) in situ gasification methods. Coal beds that are thinner than 14 inches (35 cm; anthracite and

TABLE 3.—*Summary of coal resource criteria*

	Depth (from Meters)	Thickness (inches or centimeters)
Identified and undiscovered resources		
Anthracite and bituminous coal	≤ 6,000 (1,800)	≥ 14 (35)
Subbituminous coal and lignite	≤ 6,000 (1,800)	≥ 30 (75)
Reserve base and inferred reserve base		
Anthracite and bituminous coal	≤ 1,000 (300)	≥ 28 (70)
Subbituminous coal	≤ 1,000 (300)	≥ 60 (150)
Lignite	≤ 500 (150)	≥ 60 (150)
Reserves, marginal reserves, and inferred reserves[1] (Criteria same as reserve base and inferred reserved base but with factors based on engineering and economic analysis applied.)		
Subeconomic resources		
Anthracite and bituminous coal	0–1,000 (300)	14 (35)–28 (70)
	1,000 (300)–6,000 (1,800)	≥ 14 (35)
Subbituminous coal	0–1,000 (300)	30 (75)–60 (150)
	1,000 (300)–6,000 (1,800)	≥ 30 (75)
Lignite	0–300 (150)	30 (75)–60 (150)
	500 (150)–6,000 (1,800)	≥ 30 (75)

[1] The metric thicknesses shown in parentheses are not exact equivalents of the thicknesses shown in feet, for convenience they have been rounded to the amounts shown.

[2] Includes some beds that are thinner and (or) deeper than the general criteria permit, but that are being mined currently.

bituminous) and 30 inches (75 cm; lignite and subbituminous) generally are excluded from resource consideration unless currently being mined. All coal beds deeper than 6,000 feet (1,800 m) are excluded. These limits are imposed as the result of consultations with geologists and mining engineers throughout the international coal community. In the United States, beds that contain more than 33 percent ash also are excluded; because of a shortage of energy in some countries, however, coal containing more than 33 percent ash is being mined and is classified as reserves.

Coal beds thinner or more deeply buried than the imposed limits have been mined locally at several places in the United States and are mined in other parts of the world, however, their extraction in the United States has generally not proven economic. Where such mining is taking place, the coal should be classed as a reserve and recorded at the time of assessment in the coal resource figures. With the few exceptions owing to current mining and similar future exceptions, the imposed limits should be adhered to. See general guideline No. 7, p. 32.

SPECIFIC CRITERIA

Note.—Specific criteria and glossary terms are cross-referenced within this report. To aid the reader, specific criteria, beginning below, are printed in ***boldface italics***, and glossary items, beginning on p. 5, are printed in **boldface** type.

anthracite and bituminous coal reserves.—Tonnage estimates for these classes of coal are determined by summing the recoverable quantities of coal in the reserve base and are assigned to the following categories: (a) thickness of coal—28 to 42 inches (70 to 105 cm), 42 to 84 inches (105 to 215 cm), 84 to 168 inches (215 to 430 cm), more than 168 inches (>430 cm); and (b) thickness of overburden—0 to 500 feet (0 to 150 m) and 500 to 1,000 feet (150 to 300 m). Tonnage estimates for the bituminous coal class may be divided into low-volatile, medium-volatile, high-volatile A, high-volatile B, and high-volatile C groups. Similarly, tonnage estimates for the anthracite class may be divided into meta-anthracite, anthracite, and semianthracite groups. Reserves assigned to these coal classes must be considered as economically producible at the time of classification, but facilities for extraction need not be in place and operative. See specific instruction No. 3, p. 34.

anthracite and bituminous coal inferred reserves.—Tonnage estimates for these classes of coal are determined by summing the recoverable quantities of coal in the inferred reserve base and are assigned to the same coal thickness and overburden thickness categories as anthracite and bituminous coal reserves. Inferred reserves must be considered as economically producible at the time of classification. Facilities for extraction need not be in place and operative.

anthracite and bituminous coal marginal and inferred marginal reserves.—Tonnage estimates for these classes of coal are determined by summing the marginally recoverable quantities of coal in the reserve base and in the inferred reserve base and are assignable to the same categories of thickness of coal and overburden described for anthracite and bituminous coal reserves. These classes of coal may be divided into the same rank groups as described for anthracite and bituminous coal reserves. Marginal and inferred marginal reserves must be considered uncertain as to economic producibility at the time of classification. Facilities for extraction need not be in place and operative.

anthracite and bituminous coal reserve base and inferred coal reserve base.—See ***reserve base*** for thickness of coal and thickness of overburden criteria.

anthracite and bituminous coal resources.—Tonnage estimates for these classes of coals are determined by summing the estimates for anthracite and bituminous coal identified and undiscovered resources (fig. 3). They are assignable to the same thickness categories as for anthracite and bituminous coal reserves with the addition of a 14–28 inch (35–70 cm) category (see specific instruction No. 3, p. 34), and the following overburden categories are to be recognized: 0 to 500 feet (0 to 150 m); 500 to 1,000 feet (150 to 300 m); 1,000 to 2,000 feet (300 to 600 m); 2,000 to 3,000 feet (600 to 900 m); and 3,000 to 6,000 feet (900 to 1,800 m). Tonnage estimates for the bituminous coal class may be divided into the low-volatile, medium-volatile, high-volatile A, high-volatile B, and high-volatile C groups, and tonnage estimates for the anthracite class may be divided into the meta anthracite, anthracite, and semianthracite groups.

cumulative depletion.—*Cumulative depletion* is summed from all coal extracted and lost-in-mining prior to the date of the estimate, which may be subdivided on the basis of rank and subrank (class and group) of coal, overburden class, thickness class, mining method, heat value, usage, time, cokeability, chemical constituents, and area of production.

cummulative production.—*Cummulative production* is summed from production from a mine, field, basin, region, province, state, or nation prior to the date of the estimate, which may be subdivided on the basis of rank and subrank (class and group) of coal, overburden class, thickness class, mining method, heat value, usage, time, cokeability, chemical constituents, and area of production.

demonstrated reserves and ***demonstrated marginal reserves.***—Tonnage estimates for these categories of coal are the sum of the estimates for measured and indicated reserves and marginal reserves, respectively, which are the preferred usages. See Reserves and Marginal Reserves, p. 18.

demonstrated reserve base.—Tonnage estimates for this category of coal are determined by summing the estimates for the measured and indicated reserves bases. The *demonstrated reserve base* is the same as the "reserve base," which is the preferred usage. See **reserve base**, p. 19).

demonstrated resources.—Tonnage estimates for this category are the sum of the estimates for the reserve base and subeconomic resources.

economic resources.—An informal term used by geologists to indicate their estimates of the coal resources that are potentially economic.

hypothetical resources.—Tonnage estimates for this category of resources are for (1) extensions of inferred resources (coal beyond a radius of 3 miles or 4.8 km from a point of measurement), and (2) regions where tonnage estimates are based on a knowledge of the geologic character of coal. *Hypothetical resources* include coal that is 14 inches (35 cm) or more thick (anthracite and bituminous coal) and 30 inches (70 cm) or more thick (subbituminous coal and lignite) to a depth of 6,000 feet (1,800 m). (See section on "Extrapolated Bed Map Method," p. 37; and "Extrapolated Coal Zone Method," p. 38; see also fig. 4.)

identified resources.—Tonnage estimates for this category of resource include all bituminous coal and anthracite 14 inches (35 cm) or more thick and all subbituminous coal and lignite 30 inches (75 cm) or more thick from the surface to a depth of 6,000 feet (1,800 m) whose location, rank, quality, and quantity have been determined within specified degrees of reliability as demonstrated, measured, indicated, and inferred.

indicated.—Virgin coal that lies between 1/4 mile (0.4 km) and 3/4 mile (1.2 km) from a point of thickness of coal measurement. (See fig. 4.)

indicated marginal reserves.—Tonnage estimates for this category of reserves include those parts of an indicated reserve base that at the time of determination border on being economically producible assuming certain projected economic or technologic changes. The assumed changes and the specific criteria suggesting potential economic profitability should be documented. (See **indicated**, p. 10; and fig. 4.)

indicated reserves.—*Indicated reserves* are estimated from an indicated reserve base by subtracting the assumed tonnage of coal that will be lost-in-mining and indicated marginal reserves. The remaining tonnage—the coal that is assumed will be extracted—is the *indicated reserves*, which must be considered as economically producible at the time of classification. However, facilities for extraction need not be in place and operative. (See **indicated**, p. 10; and fig. 4.)

indicated reserve base.—An *indicated reserve base* is determined by projection of thicknesses of coal and overburden, rank, and quality data from points of measurement and sampling on the basis of geologic evidence using the following criteria: (a) individual points of measurement are bounded by measured coal for 1/4 mile (0.4 km) succeeded by indicated coal from 1/4 mile (0.4 km) to 3/4 mile (1.2 km); and (b) *indicated reserve base* includes anthracite and bituminous coal 28 inches (70 cm) or more thick and subbituminous coal 60 inches (150 cm) or more thick to depths of 1,000 feet (300 m) and lignite 60 inches (150 cm) or more thick to depths of 500 feet (150 m). (See **indicated**, p. 10.)

indicated resources.—Tonnage estimates for *indicated resources* are computed by projection of thicknesses of coal and overburden, rank, and quality data from points of measurement and sampling on the basis of geologic evidence and are assigned to the following categories: (a) individual points of measurement are bounded by measured coal for 1/4 mile (0.4 km) succeeded by 1/2 mile (0.8 km) of indicated coal; and (b) *indicated resources* include anthracite and bituminous coal 14 inches (35 cm) or more thick and lignite and subbituminous coal 30 inches (75 cm) or more thick to a depth of 6,000 feet (1,800 m). The quantity of coal estimated as *indicated resources* is the same as the sum of the indicated reserve base, and indicated subeconomic resources. (See **indicated**, p. 10; and fig. 4.)

inferred.—Virgin coal that lies between 3/4 mile (1.2 km) and 3 miles (4.8 km) from a point of thickness of coal measurement. (See fig. 4.)

inferred marginal reserves.—Tonnage estimates for this category of reserves include those parts of an inferred reserve base that at the time of determination border on being economically producible assuming certain projected economic or technologic changes. The assumed changes and the specific criteria suggesting potential economic profitability should be documented. (See **inferred**, p. 10; and fig. 4.)

inferred reserve base.—An *inferred reserve base* is determined by projection of thicknesses of coal and overburden, rank, and quality data from points of measurement and sampling on the basis of geologic evidence using the following criteria: (a) individual points of measurement are bounded by measured and indicated coal for 3/4 mile (1.2 km) succeeded by inferred coal from 3/4 mile (1.2 km) to 3 miles (4.8 km), and (b) *inferred reserve base* includes anthracite and bituminous coal 28 inches (70 cm) or more thick, subbituminous coal 60 inches (150 cm) or more thick, all to depths of 1,000 feet (300 m), and lignite 60 inches (150 cm) or more in thickness to depths of 500 feet (150 m).

inferred reserves.—*Inferred reserves* are estimated from the inferred reserve base by subtracting the inferred marginal reserves and the coal that is estimated will be lost-in-mining. *Inferred reserves* must be considered as economically producible at the time of determination considering environmental, legal, and technologic constraints. Extraction facilities need not be in place and operative.

inferred resources.—*Inferred resources* are determined by projecting the thicknesses of coal and overburden, rank, and quality data from points of measurement and sampling on the basis of geologic knowledge and are assigned to the following categories: (a) individual points of measurement are bounded by measured and indicated coal for 3/4 mile (1.2 km) succeeded by 2-1/4 miles (3.6 km) of inferred coal; (b) *inferred resources* include anthracite and bituminous coals 14 inches (35 cm) or more thick and lignite and subbituminous coal 30 inches (75 cm) or more thick to depths of 6,000 feet (1,800 m). The quantity of coal estimated as an inferred resource is the same as the sum of the inferred reserve base and inferred subeconomic resources.

lignite reserves.—Tonnage estimates for this class of coal reserves are determined by summing the recoverable quantities of coal in the reserve base and are assigned to the following categories: (a) thickness of coal—5 to 10 feet (1.5 to 3.0 m), 10 to 20 feet (3 to 6 m), 20 to 40 feet (6 to 12 m), and more than 40 feet (>12 m); and (b) thickness of overburden—0 to 500 feet (0 to 150 m). Tonnage estimates for *lignite reserves* may be divided into the lignite A and B groups. Reserves assigned to the lignite class must be considered as economically producible at the time of classification, but facilities for extraction need not be in place and operative.

Discussion: Currently, there are few underground ground lignite mines in the United States. In addition, there are few, if any, lignite strip mines that are removing as much as 300 feet (100 m) of overburden. In order to provide for future technologic and surface mining advances, the maximum thickness of overburden for surface-minable *lignite reserves* and reserve base is set at 500 feet (150 m). It is deemed inexpedient to estimate underground-minable *lignite reserves* and reserve base at depths greater than 500 feet (150 m). (See specific instruction No. 3, p. 34.)

lignite marginal and inferred marginal reserves.—Tonnage estimates for these classes of coal reserves are determined by summing the marginally recoverable quantities of coal in the reserve base and inferred reserve base and are assignable to the same categories of thicknesses of coal and overburden described for lignite reserves; coal may be divided into the lignite A and B groups. *Lignite marginal and inferred marginal reserves* must be considered as uncertain as to their economic producibility at the time of classification. Facilities for extraction need not be in place and operative.

lignite inferred reserves.—Tonnage estimates for this class of reserves are determined by summing the recoverable quantities of coal in the inferred reserve base and are assignable to the same categories of thicknesses of coal and overburden described for lignite reserves. Also, this class of coal may be divided into the lignite A and B groups. Such inferred reserves must be considered economically producible at the time of classification; facilities for extraction need not be in place and operative.

lignite reserve base and inferred reserve base.—See ***reserve base*** for thickness of coal and thickness of overburden criteria.

lignite resources.—Tonnage estimates for this class of coal are determined by summing the estimates for lignite identified and undiscovered resources. The same thickness categories as for lignite reserves are to be used with the addition of a 30-60 inches (75-150 cm) category (see specific instruction No. 3, p. 34), and the following overburden categories are to be recognized: 0 to 500 feet (0 to 150 m); 500 to 1,000 feet (150 to 300 m), 1,000 to 2,000 feet (300 to 600 m), 2,000 to 3,000 feet (600 to 900 m); and 3,000 to 6,000 feet (900 to 1,800 m). The tonnage estimates for this class of coal may be divided into lignite A and B groups.

measured.—Accessed and virgin coal that lies within a radius of 1/4 mile (0.4 km) of a point of thickness of coal measurement. (See fig. 4.)

measured marginal reserves.—Accessed and virgin coal that lies within a radius of 1/4 mile (0.4 km) of a point of thickness of coal measurement. Tonnage estimates for this category of reserves includes those parts of a measured reserve base that at the time of determination border on economic producibility assuming certain projected economic or technologic changes. The assumed changes and the specific criteria suggesting potential economic producibility should be documented. (See **measured**, p. 12; and fig. 4.)

measured reserves.—*Measured reserves* are estimated from a measured reserve base by subtracting the sum of the assumed tonnage of coal that will be lost-in-mining and measured marginal reserves. The remaining tonnage—the coal that is assumed will be extracted—is *measured reserves* which must be considered as economically producible at the time of classification; however, facilities for extraction need not be in place and operative.

measured reserve base.—A *measured reserve base* is determined by projection of thicknesses of coal and overburden, rank, and quality data from points of measurement and sampling on the basis of geologic evidence for a radius of 1/4 mile (0.4 km). A *measured reserve base* includes anthracite and bituminous coal 28 inches (70 cm) or more thick and subbituminous coal 60 inches (150 cm) or more thick to depths of 1,000 feet (300 m) and lignite 60 inches (150 cm) or more thick to depths of 500 feet (50 m).

measured resources.—Tonnage estimates for *measured resources* are computed by projection of thicknesses of coal and overburden, rank, and quality data for a radius of 1/4 mile (0.4 km) from a point of measurement. Measured resources include anthracite and bituminous coal 14 inches (35 cm) or more thick and lignite and subbituminous coal 30 inches (75 cm) or more thick to depths of 6,000 feet (1,800 m). The quantity of coal estimated as measured is the same as the sum of the measured reserve base and measured subeconomic resource.

original resources.—Tonnage estimates determined for coal in the ground prior to production. Where coal has been mined, estimates are made by summing remaining resources, cummulative production, and coal lost-in-mining. An estimate of total original resources is the sum of the original resources determined for many mines, fields, basins, regions, provinces, States, and the Nation. (See ***resources*** for thicknesses of coal and overburden; and **lost-in-mining**, p. 12.)

other occurrences, noneconomic coal.—Such coal, except where mined locally, consists of anthracite and bituminous coal beds less than 14 inches (35 cm) thick; lignite and subbituminous coal beds less than 30 inches (75 cm) thick; and all coal beds that are buried by more than 6,000 feet (1,800 m) of overburden; coal containing more than 33 percent ash; and that coal lost-in-mining that is considered noneconomic. Tonnage estimates are optional for such coal. However, if estimates are made, they should be reported as "other occurrences" and not

as resources. However, where currently mined, coal that is considered too thin or too high in ash and would normally be classed as "other occurrences" is to be classed as reserves.

rank assignments.—The assignment of rank is a necessary part of classifying a coal; however, data for determining rank are commonly sparse or are far-removed from the localities where the data required for rank assignment is needed. In general, rank gradually changes laterally over many miles or stratigraphically over hundreds to thousands of feet. Because of the lack of data in some areas, conclusions concerning *rank assignments* commonly must be derived from analytic or petrographic determinations made on coal that lies some distance from where the rank assignment is desired. Conclusions concerning rank where analytic or petrographic data are sparse must be viewed as tentative. However, if a geologist's understanding of the setting of the area sampled is adequate, the rank assignment probably will be correct even though the rank data are sparse.

rank calculation.—The rank of coal is to be calculated by using the following instructions which are quoted from the standard specifications for classification of coals by rank (ASTM Standards, 1981, p. 212-216):

8. Calculation to Mineral-Matter-Free Basis

8.1 *Calculation of Fixed Carbon and Calorific Value.* For classification of coal according to rank, fixed carbon and calorific value shall be calculated to the mineral-matter-free basis in accordance with either the Parr formulas, Eqs 1, 2, and 3, or the approximation formulas, Eqs 4, 5 and 6, that follow. In case of litigation use the appropriate Parr Formula.

8.2 Calculation to Mm-free basis.

Parr Formulas

$$\text{Dry, Mm-free FC} = \frac{(\text{FC} - 0.15\text{S})}{[100 - (\text{M} + 1.08\text{A} + 0.55\text{S})]} \times 100 \quad (1)$$

$$\text{Dry, Mm-free VM} = 100 - \text{Dry, Mm-free FC} \quad (2)$$

$$\text{Moist, Mm-free Btu} = \frac{(\text{Btu} - 50\text{S})}{[100 - (1.08\text{A} + 0.55\text{S})]} \times 100 \quad (3)$$

Note—The above formula for fixed carbon is derived from the Parr formula for volatile matter.

Approximation Formulas

$$\text{Dry Mm-free FC} = \frac{\text{FC}}{[100 - (\text{M} + 1.1\text{A} + 0.1\text{S})]} \times 100 \quad (4)$$

$$\text{Dry, Mm-free VM} = 100 - \text{Dry, Mm-free FC} \quad (5)$$

$$\text{Moist, Mm-free Btu} = \frac{\text{Btu}}{[100 - (1.1\text{A} + 0.1\text{S})]} \times 100 \quad (6)$$

where

Mm = Mineral matter,
Btu = British thermal units per pound (calorific value),
FC = percentage of fixed carbon,
VM = percentage of volatile matter,
M = percentage of moisture,
A = percentage of ash, and
S = percentage of sulfur

Above quantities are all on the inherent moisture basis. This basis refers to coal containing its natural inherent or bed moisture but not including water adhering to the surface of the coal.

recovery factor method.—Only a part of the coal in any deposit can be extracted when mined. The coal not extracted during underground mining, strip mining, or auger mining; the coal that becomes a part of a underground or strip-mine waste pile; or the coal that is not removed adjacent to a strip-mine or underground-mine boundary is considered as lost-in-mining unless sufficient tonnages are left unextracted so that additional mining or recovery can be foreseen.

If it is not feasible or possible to calculate the reserves of an area using an economic analysis, a reasonable approximation of the reserves can be determined by using the *recovery factor method* described hereafter.

Each operating mine has a unique percentage of coal that is recovered. This percentage is termed the recovery factor of the mine and is obtained from the following formula:

$$RF = \frac{Y \times 100}{X}$$

where

RF = Recovery factor or percent coal estimated extractable during mining,
X = The total tonnage of coal estimated in the ground,
Y = The tonnage of coal estimated to be recoverable during mining.

A recovery factor can be applied to a reserve base to obtain an estimate of the reserves of an area. Such use of a recovery factor is appropriate when there is a paucity of geologic data for estimating the tonnage of potentially extractable coal.

It is difficult to estimate accurately the recoverable coal in a very large area such as a field, region, province, basin, State, or the Nation because it is impossible to determine how much coal in the area will not be mined for legal or environmental reasons, what method

or methods of mining will be used, and what the average recovery factor will be for all mining methods.

A reserve base and reserves have been estimated by industry for most operating mines in the United States. Generally, data that can be used to compute recovery factors for individual mines are closely held by the operators; therefore, there is little publicly available information to guide estimators in determining local, regional, and national recovery factors. Commonly, estimators must extrapolate recovery factors from experience gained in a few mines by assuming that (1) geologic conditions controlling mining will be similar, and (2) success in the recovery of coal in unmined areas will be similar to that of mined areas utilizing the same mining method. Such extrapolation of recovery factors from a few well known mined areas to less well known or unknown areas requires experience regarding the geology, the mining method or methods to be employed, and an awareness of the difficulties, geologic and otherwise, that affect the estimation of reserves. Area, quadrangle, township, field, basin, province, county, State, and national recovery factors can be determined by using formulas after determining the mean recovery factor in percent for many mines, ascertaining the quantity of reserve base coal in the area of study, and ascertaining the total quantity of coal that is restricted from mining for any legal, environmental or technologic reason. These formulas are:

$$Z = 100\ \frac{X}{Y}$$

$$NRF = W(100 - Z)$$

where

X = tonnage of coal restricted from extraction for any legal, environmental, or technologic reason,

Y = tonnage of coal included in the reserve base category of a large area,

Z = restricted coal (percent),

W = recovery factor percent obtained from local mines, and

NRF = National, State, or large area recovery factor in percent applied to all coal including restricted.

In the United States, recovery factors for underground mining as determined from mine maps of abandoned and operating mines generally range from about 35 to about 70 percent and average about 50 percent. Similarly, recovery factors for abandoned and operating surface mines range from about 70 to 95 percent and average about 80 percent. These local recovery factors are valid for individual mines but are not valid for large areas because they fail to consider the coal lost-in-mining such as (1) the coal that will not be mined between properties, and (2) coal in overlying and underlying beds rendered usuitable for future mining by past underground mining. Further, the local recovery factors do not consider the coal that is restricted or prohibited from mining, such as the coal underlying national parks and wild life sanctuaries; coal that is too deep and too thin to be mined because of excessive costs; and coal that cannot be mined because of unsolved technologic, geologic, or engineering problems.

The authors recommend applying a recovery factor of 50 percent to the reserve base when computing underground and surface mining reserves of large areas. However, if actual local recovery factors have been calculated, the procedure outlined with the two formulas should be implemented for smaller areas.

remaining resources.—The resources remaining in the ground after prior mining. These resources include identified and undiscovered resources and include coal lost-in-mining whose attributes indicate possible future recovery. See ***resources***, for thickness of coal and overburden criteria, and figure 3.

reserve base.—A tonnage estimate for this category of coal consists of the sum of the estimates for measured and indicated reserves, marginal reserves, and a part of the measured and indicated subeconomic resources (the coal that has or will be lost-in-mining). The *reserve base* is the same as the demonstrated reserve base. The term *reserve base* is preferred for reports of the U.S. Geological Survey. The criteria for the *reserve base* include bituminous coal and anthracite 28 inches (70 cm) or more thick, subbituminous coal 5 feet (1.5 m) or more thick that occurs at depths to 1,000 feet (300 m), and lignite 5 feet (1.5 m) or more thick that occurs at depths to 500 feet (150 m).

Discussion: Individual reserve bases, where needed and appropriate, are to be determined by categories of reliability, thicknesses of coal and overburden; rank, chemical constituents, ash content, heat value, and potential usage. Additionally, estimated individual reserve base estimates are to be summed into totals for each township, quadrangle, coal field, basin, region, province, township and range, county, State, and the Nation. Assignment of coal to a reserve

base is controlled by physical and chemical criteria such as categories of reliability, thicknesses of coal and overburden, rank of coal, and knowledge of depositional patterns of coal beds and associated structural features. Changing economic, technologic, and environmental considerations do not control assignment of coal to a reserve base. In contrast, the discrimination of reserves is largely controlled by economic factors such as judgments of cost, profit, and supply of and demand for coal. Reserve discrimination is controlled secondarily by advances or differences in mining, preparation and transportation technologies, and by environmental regulations, laws, and judicial rulings.

The physical and chemical criteria used to assign coal to a reserve base category have been used already to evaluate many coal beds that are currently mined in the United States. These evaluations indicate coal assigned to a reserve that is derived from a physically-chemically defined *reserve base* can be expected to be economically minable with a high degree of confidence. In a few places, however, where the thickness of a coal bed or associated rock conditions are exceptionally variable or severe, the varying tonnages of coal classified as a reserve from a physically and chemically defined *reserve base* may or may not prove to be extractable at a profit.

Changes in environmental laws and regulations generally affect the tonnages of coal assigned to the various categories of the *reserve base*, however, assessments of these changes have not been made.

reserves.—Reserve tonnage estimates are to be determined by summing the recoverable quantities of coal in the reserve base for each rank of coal and are assigned to the following categories: (1) thickness of overburden—0 to 500 feet (0 to 150 m) and 500 to 1,000 feet (150 m to 300 m); and (2) thickness of coal—28 to 42 inches (70 to 105 cm), 42 to 84 inches (105 to 215 cm), 84 to 168 inches (215 to 430 cm), and more than 168 inches (> 430 cm) for anthracite and bituminous coal; and 5 to 10 feet (1.5 to 3.0 m), 10 to 20 feet (3.0 to 6.0 m), 20 to 40 feet (6.0 to 12.0 m), and more than 40 feet (> 12.0 m) for subbituminous coal and lignite. (See specific instruction No. 3, p. 34.) *Reserves* must be considered as economically producible at the time of classification, but facilities for extraction need not be in place and operative. In addition, categories based on potential mining methods (surface and underground); chemical constituents such as sulfur, phosphorous and ash content; heat value; and usage such as metallurgical, steam, petrochemical, gasification, and liquefaction are desirable. *Reserves* and marginal reserves are estimated by determining the amount of coal in each reserve base category that can be extracted at the time of classification (*reserves*), and the amount that borders on being extractable at a profit (marginal reserves). These two amounts and the amount that will be lost-in-mining, when summed, are equal to the reserve base. The estimates of each reserve category are to be totaled into quadrangle, township, field, basin, region, province, county, and State estimates, and into a national total, and then the various estimates for all categories are to be totaled similarly to reach an inclusive estimate of all *reserves*.

Reserves are derived from the reserve base, which includes bituminous coal and anthracite 28 inches (70 cm) or more thick, subbituminous coal 5 feet (1.5 m) or more thick that occurs at depths to 1,000 feet (300 m), and lignite 5 feet (1.5 m) or more thick that occurs at depths to 500 feet (150 m). *Reserves* also include thinner and (or) more deeply buried beds of these ranks of coal that are currently being mined.

resources.—Tonnage estimates for coal resources are determined by summing the estimates for identified and undiscovered deposits of coal that are 14 inches (35 cm) or more thick for anthracite and bituminous coal and under less than 6,000 feet (1,800 m) of overburden, and 30 inches (75 cm) or more thick for lignite and subbituminous coal and under less than 6,000 feet (1,800 m) of overburden.

speculative resources.—As of publication of this circular, there are no speculative resources of coal estimated for the United States. However, if it is desirable to make such estimates, the definition of Speculative Resources (p. 20) and the criteria for *resources* will be followed, and the geologic evidence supporting the estimates and methods of quantification will be made available publicly.

subbituminous coal inferred reserves.—Tonnage estimates for this class of coal are determined by summing the recoverable quantities of coal in the inferred reserve base and are assigned to the same categories of thickness of coal and overburden described for *subbituminous coal reserves*. This class of coal may be divided into the same rank groups as described for *subbituminous coal reserves*. Inferred reserves must be considered as economically producible at the time of classification. However,

facilities for extraction need not be in place and operative.

subbituminous coal marginal and inferred marginal reserves.—Tonnage estimates for these classes of coal are determined by summing the marginally recoverable quantities of coal in the reserve base and inferred reserve base, respectively, and are assigned to the same categories of thicknesses of coal and overburden described for ***subbituminous coal reserves***. These classes of coal may be divided into the same rank groups as described for ***subbituminous coal reserves***. Marginal and inferred marginal reserves must be considered uncertain as to their economic producibility at the time of classification. Facilities for extraction need not be in place and operative.

subbituminous coal reserves.—Tonnage estimates for this class of coal are determined by summing the recoverable quantities of coal in the reserve base and are assigned to the following categories: (a) thickness of coal—5 to 10 feet (1.5 to 3.0 m), 10 to 20 feet (3.0 to 6.0 m), 20 to 40 feet (6.0 to 12.0 m), and more than 40 feet (> 12.0 m) (see specific instruction No. 3, p. 34); and (b) thickness of overburden—0 to 500 feet (0 to 150 m) and 500 to 1,000 feet (150 to 300 m). Such reserve estimates may be divided into subbituminous A, B, and C rank groups. Reserves assigned to this coal class must be considered as economically producible at the time of classification, but facilities for extraction need not be in place and operative.

subbituminous coal reserve base and inferred reserve base.—See ***reserve base*** for thickness of coal and thickness of overburden categories.

subbituminous coal resources.—Tonnage estimates for this class of coals are determined by summing the estimates for identified and undiscovered subbituminous coal resources. The same thickness categories as for subbituminous coal reserves are to be used with the addition of a 30 inches-5 feet (75 cm-1.5 m) category (see specific instruction No. 3, p. 34), and the following overburden categories are to be recognized: 0 to 500 feet (0 to 150 m); 500 to 1,000 feet (150 to 300 m); 1,000 to 2,000 feet (300 to 600 m); 2,000 to 3,000 feet (600 to 900 m); and 3,000 to 6,000 feet (900 to 1,800 m). Such resource estimates may be divided into subbituminous coal A, B, and C rank groups.

subeconomic resources and inferred subeconomic resources.—Tonnage estimates for these classes of coal are determined by summing the estimates for measured, indicated, and inferred resources that do not meet the criteria for assignment to the reserve base or inferred reserve base because they are too thin to mine, are too deeply buried to mine, or are those parts of the reserve base or inferred reserve base that have been or will be lost-in-mining but whose attributes indicate future recovery may become feasible. Included are all measured, indicated, and inferred reliability categories of bituminous coal and anthracite beds 14 to 28 inches (35 to 70 cm) thick, all subbituminous coal beds 30 to 60 inches (75 to 150 cm) thick that are less than 1,000 feet (300 m) below the surface, and all lignite beds 30 to 60 inches (75 to 150 cm) thick that are less than 500 feet (< 150 m) below the surface, unless the coal in these beds will be recovered in the process of extracting coal from thicker beds. Also included are all beds of bituminous coal and anthracite 14 inches (35 cm) or more thick and beds of subbituminous coal 30 inches (75 cm) or more thick that occur at depths between 1,000 and 6,000 feet (300 and 1,800 m) and lignite beds 30 inches (75 cm) or more thick and more than 500 feet (> 150 m) below the surface.

thickness of coal for resource calculations.—The thickness of coal used for resource calculations is the net thickness of coal in a bed excluding all partings more than 3/8 inch (> 1 cm) thick. Beds and parts of beds made up of alternating layers of thin coal and partings are omitted from calculations if the partings comprise more than one-half of the total thickness. Also, benches of anthracite and bituminous coal less than 14 inches (35 cm) thick and benches of subbituminous coal and lignite less than 30 inches (75 cm) thick are omitted from calculations if they lie above or below partings that may deter their mining. Coal and coaly material containing more than 33 percent ash is excluded from resource and reserve estimates unless the ash is largely in associated partings so that the coal is cleanable to less than 33 percent ash. (See **parting**, p. 15, and specific instruction No. 13, p. 36.)

undiscovered resources.—Tonnage estimates for this category of resources are based (1) on knowledge of the geologic character, habit, and pattern of a coal bed or coal zone in an area or region or (2) on speculative geologic data. Estimates are made by summing the tonnage estimates for coal assigned to the hypothetical and speculative resources reliability categories. Included are hypothetical and speculative resources of bituminous coal and anthracite in beds 14 inches (35 cm) or more

thick and hypothetical and speculative resources of subbituminous coal and lignite in beds 30 inches (75 cm) or more thick presumed to occur in mapped areas and in unmapped or unexplored areas to depths of 6,000 feet (1,800 m).

GUIDELINES FOR ESTIMATING COAL RESOURCES

These guidelines were prepared so that coal-resource workers will have logical and uniform procedures to follow. They combine the best features of the procedures used in preparing many previously published estimates of State and national coal resources with additions and modifications from numerous conferences with experienced coal resource estimators.

These guidelines are aimed at producing a uniformity of procedures so that coal-resource estimates prepared by various individuals and groups can be compared and (or) combined into meaningful totals for a quadrangle, township and range, coal field, basin, region, province, county, state, nation, continent, and (or) the world.

Some statements in the guidelines obviously are not rigidly applicable to all coal beds or coal-bearing areas. Where such shortcomings are perceived, a logical procedure is to develop new guidelines to effect appropriate changes in methodology so that they can be studied, criticized, and accepted or rejected by others.

The following statements are to be strictly adhered to by all coal resource specialists in the U.S. Geological Survey: *(1) All tables of coal resource or reserve estimates must contain a date and appropriate authorship information; and (2) each table of coal resource or reserve estimates must show where supporting basic data were located at the time of estimation.*

GENERAL GUIDELINES FOR CLASSIFICATION OF COAL RESOURCES

These general guidelines are required for uniform classification and reporting of coal into the different resource categories. They are modeled after the guidelines in Circular 831 (U.S. Geological Survey, 1980, p. 3-4) for all minerals.

1. All naturally occurring concentrations of coal can be distributed into one or more of the classification categories.
2. Where the term "reserves" is used without a modifying adjective, for example, marginal, indicated, restricted, low-sulfur, or inferred, it is to be considered synonomous with the demonstrated-economic category.
3. Quantities and qualities of coal may be expressed in a variety of terms and units to suit different purposes but must be clearly stated and defined.
4. A reserve base is a resource category delineated only by physical and chemical criteria. A major purpose for the recognition and discrimination of a reserve base is to aid in long-range public and commercial planning. A reserve base estimate for specific rank, thicknesses of coal and overburden, quality, usage, geologic formation, age, depositional environment, and many other factors can be specified for any given deposit or area, or for the Nation. The position of the lower boundary of a reserve base is intended to extend into the subeconomic category. The intention of this extension is to define quantities of in-place material, parts of which may become economic depending on the extraction plan finally utilized. As a result of any given extraction plan, the reserve base can be subdivided into component parts—reserves, marginal reserves, and a remnant of subeconomic resources. For the purpose of Federal (USGS) assessment, criteria for the reserve base are listed on page 29 of this report.
5. Undiscovered resources should be subdivided in accordance with the definitions of hypothetical and speculative resources or they may be subdivided in terms of relative probability of occurrence (see figs. 1 and 2).
6. Inferred reserves and the inferred reserve base represent postulated extensions of reserves and the reserve base. They are identified resources but are quantified with a relatively low degree of certainty. Postulated quantities of resources based on geologic inference alone should be assigned to the undiscovered categories.
7. Locally, limited quantities of coal may be produced from beds that are of insufficient thickness or are too deeply buried to be classified as reserves. This situation arises when production facilities are already established or when favorable local circumstances, such as particular coal qualities or removal of overburden for other purposes, make it possible to produce coal that otherwise could not be extracted profitably. Where such production is occurring, the quantity of in-place coal (including coal for in situ gasification) shall be included in a reserve base and the quantity that is potentially producible shall be documented as reserves. The profitable production of such coal, however, should not be used as a rationale to assign a reserves classification to coal in other areas having similar overburden, thickness of coal, and qualities.
8. Coal resources classified as reserves must be considered as economically producible at the time of

classification. Conversely, coal not currently producible at a profit cannot be classified as reserves. However, there are situations in which mining plans are being made, lands are being acquired, or mines and plants are being constructed to produce coal that does not meet economic criteria for reserve classification under current costs and prices but that would do so under reasonable future projections and expectations. The marginal reserve category applies to such situations. When economic production appears certain, coal classified as marginal reserves will be reclassified as reserves. Marginal reserves also may include any other coal whose economic producibility borders on being profitable.

9. Tonnage of coal that is too impure, too thin, too deep, or for other reasons not considered to be potentially economic may be estimated, but is not to be classified as a resource. These tonnages may be classified in the box labeled "other occurrences" in figures 1, 2, and 3.
10. Rank classes of coal, for example, bituminous coal as distinct from lignite, should be separately quantified.
11. The amount of cumulative production is not a part of the remaining coal resources. However, an understanding of what has been produced in the past is important to resource understanding, both in terms of the amount of production and the amount of coal remaining in place. Separate accounting for cumulative production should be made for each report area, county, State, and the Nation.
12. By-passed coal in large blocks left in the ground during mining, or planned to be left in the ground during current or future extraction, should be recorded in an appropriate resource category depending upon its economic recovery potential. Coal lost-in-mining should also be recorded in an appropriate resource category if there is a potential for further recovery.
13. In classifying reserves and resources it may be necessary to recognize locally that some coal deposits derive their economic viability from coproduct or byproduct relationships with other commodities.
14. Factors other than economic and geologic considerations, including legal, regulatory, environmental, and political concerns, may restrict or prohibit the utilization of all or part of a coal deposit. Reserve and resource quantities known to be restricted should be recorded as such in an appropriate category.
15. This classification system allows for the presentation of more subdivisions than will commonly be reported or for which data are available. Where appropriate, subdivisions may be aggregated or omitted.
16. Data supporting resource estimates are to be documented and preserved.

SPECIFIC INSTRUCTIONS

1. RANK OF COAL

Where coal of more than one rank class or rank group is covered by an individual report, the resource data shall be reported separately for each major rank class and when possible for each rank group listed below:

Class	Rank group	Abbreviation
Anthracite	Meta-anthracite	ma
Do	Anthracite	an
Do	Semianthracite	sa
Bituminous coal	Low-volatile bituminous coal	lvb
Do	Medium-volatile bituminous coal	mvb
Do	High-volatile A bituminous coal	hvAb
Do	High-volatile B bituminous coal	hvBb
Do	High-volatile C bituminous coal	hvCb
Subbituminous coal	Subbituminous A coal	subA
Do	Subbituminous B coal	subB
Do	Subbituminous C coal	subC
Lignite	Lignite A	ligA
Do	Lignite B	ligB

Abbreviations can be used wherever appropriate in reports and tables.

2. OVERBURDEN

Tonnage estimates shall be reported according to thickness of overburden:

Mandatory underground mining categories	Mandatory and optional surface mining categories[1]
0 to 500 feet (0 to 150 m)	0 to 500 feet (0 to 150 m) mandatory use
500 to 1,000 feet (150 to 300 m)	0 to 100 feet (0 to 30 m) optional use
1,000 to 2,000 feet (300 to 600 m)	100 to 200 feet (30 to 60 m) optional use
2,000 to 3,000 feet (600 to 900 m)	0 to 200 feet (0 to 60 m) optional use
3,000 to 6,000 feet (900 to 1,800 m)	200 to 500 feet (60 to 150 m) optional use
Optional value recovery category	
>6,000 feet (>1,800 m)	

[1] Use of optional surface mining categories requires the complete coverage of the 0-500 feet (0-150 m) category. Other categories may be used if they are in increments of 100 feet (30 m) and do not exceed 500 feet (150 m).

Alaska Coal
Slide Presentation

Now I'm going to show you some slides. Because of limited time, I can't show you every single coal occurrence in the state. I'll start with the North Slope.

Slide Number:

1. The first location we'll look at is the most extensive coalfield in Alaska. It is possibly the last in the world.

2. The Cape Beaufort region. This is a simplification of the geology. Note the elongated shapes. This depicts the structure. These are the coal bearing synclines--the Corwin formation--Cretaceous in age. This coal is all bituminous in rank.

3. A false color IR satellite view...this is the Liz-A syncline. See how the structure stands out.

4. Here's a Simplified Geologic illustration of the syncline showing some of the mapped coal beds.

5. The Deadfall syncline--
6. Simplified geology of same--showing mapped coal beds.
This region contains coal beds up to 20 ft. thick. The Deadfall syncline and Kukpowruk River area are the most thoroughly explored, with the Liz-A syncline next. In 1983 over 5,000 ft. of drilling was completed in Deadfall syncline.

Now--let's get down to ground level---

7. The 20 ft. bed outcropping on the Kukpowruk---
8. A close-up of same. This is the location of the Morgan Coal Company lease.

9. North of Cape Beaufort--on the plain there are a few coal outcrops. Another outcrop north of Cape Beaufort. This one has been trenched for sampling.

11. Moving down the coast to Corwin Bluff, named for the ship
Corwin...Captain C.L. Hooper of the ship
12. Corwin is reported to have taken 20 tons of coal
13. from here in 1881.

14. Now for the Lisburne Peninsula. As you can see from the map...there is coal outcropping here on the coast in
15. the region of Cape Dyer. This is the Mississippian coal
16. that I mentioned...as much as 350 million years old. This is good coal..But the whole region has undergone
17. some terrific deformation...This simplified geologic map illustrates the problem. The red area here is the coal bearing formation. These black lines with teeth are thrusts...(explain "thrust" if audience is unfamiliar with the term).

18. Here's an illustration of the coal-bearing section, drawn from a series of photographs taken from the air. The numbers are those assigned to the different coal beds--starting at Niak Creek, going south--by Irving Tailleur of the U.S.G.S. in the 50's.

19. Niak Creek - This is the farthest north outcrop of coal that we could locate in 1983.

20. A couple of the coal beds. Note the deformation.

21. The continuity of a coal bed with this kind of deformation is questionable. Still...the coal is good, and accessible--and could provide fuel for Point Hope.

22. Next I'm going to skip down to Unalakleet...We did a drilling program there in 82-83.

23. Here's the coastline...the area where coal was reported. Apparently some limited mining of coal was done here around the turn of the Century. Unfortunately--
24. this is what the coal is like...seems to be limited to slump blocks in the coastal bluff. There may be more coal, but our drilling did not confirm this. More exploration is needed. Reports of coal float in creeks may indicate a more promising source inland from the coast.

25. Now let's move back up to the Seward Peninsula. DGGS investigated coal occurrences in these locations. I don't have slides of every coal occurrence, but.--

26. Here's The drill rig at Sunuk River...
27. And a shot of typical coal here. Not too exciting.

28. This is at Turner Creek - or Noxapaga...The coal occurs in a pingo. There could be some potential here.

29. Next we move to Koyuk...(USE MAP) we drilled at this location. Here is
30. a simplified geologic map...The Blue is the coal-bearing formation. Sorry...no coal pictures... There is a significant amount of coal here although it appears to occur in pod-like, discontinuous deposits.

31. This next series of slides is of Chicago Creek! (USE MAP). This is the prize that made the rest worth it. Here is a geologic illustration.

32. The Chicago Creek Coal deposit was the site of a coal mine that operated between 1908 and 1911. 100,000 tons of coal was mined through a 330 ft. inclined shaft. The coal was hauled overland to Candle and used to fire boilers for Steam-Thawing Placer deposits.

33. Here's the old Mine Site...not much left now.

34. The drill rig in place (Jim Thrasher) 1982-1983.

35. Some of the results of the drilling...coal...lots of it. A total of 68 holes, up to 500 ft. in depth were drilled as of the end of 1983. Since then, C.C. Hawley Co. has put down 47 more holes. The coal-bearing unit at Chicago Creek is confined to a long-narrow north-south trending trough. To-date...The coal bed at it's thickest point is 78 ft. thick. It varies in thickness but, so-far has been traced for 18,000-19,000 ft. along strike. Strippable reserves are calculated to be 3.4 million short tons. This coal is a lignite. BTU/lb = 7,000. It is late Tertiary in age.

I'll now move inland to the Kobuk River area. (USE MAP - POINT OUT LOCATION).
Several areas of coal occurrences were investigated along the Kobuk and it's tributaries, and in the nearby Hockley Hills.

36. Here is an occurrence on the Kallarichuk River.

37. And the Singauruk River.

38. And the Hockley Hills.

39. Now for St.Lawrence Island.

40. There is coal on St. Lawrence in several locations.

41. Portable auger drill...testing for sub-surface coal.

42. Now, I'm jumping way over to the northern Interior. This last summer, we visited the Tramway Bar coal occurrence on the middle for of the
43. Koyukuk, south of Wiseman. This is Cretaceous age coal...bituminous in rank. Good coal--but, as you can see--pretty deformed. The thickest bed is about 17 ft. thick, including a significant clay parting. Continuity of this bed is not known. It is only 4 miles from the TAP road, but is in Yukon Charley Park and Preserve.

MAP Jumping again...To the Eagle Coalfield not many shots from here...coal known all along Tintina Trough...Starting at Mission Creek...(Mention Nation River -- Bituminous...deformed show locations on map along Yukon drainage).

44. Here's a shot of coal on Sam Creek, near the Charley River.

45. Now I'll move down to
Chicken. (Show location on Map). This is the old mine adit.

46. And Tipple.

47. Coal in Dredge Tailings on Chicken Creek.

48. Preacher Creek - July this year...
49. near Circle. Jim Barker and I went up to look at the Tertiary rocks there. A thin line of coal in this creek bank turned out to indicate a +5 ft. coal bed when Jim dug into it. This hole is 7 ft. into the bank.

Now - on over to the Yukon Flats uplands. There are several reports of coal in this region...

50. Here on the Dall River in the Beaver Quadrangle - there is an 18 foot coal bed.

51. On the Hodzana River - and also on the Ray River, the Big Salt River, and the Tozitna River...(mudbank). Under Yukon Flats could be a huge coal resource

LIGHTS ON - MAP

Talk a bit about Yukon River coals---
Rampart Drew Mine, Minook Creek coal exposure, geology.

Now down to Nulato Coalfield...
In October, 1985, DGGS personnel in a cooperative reconnaissance expedition down the Yukon investigated coal occurrences from near Louden, above Galena, to below Kaltag.

52. At Louden - 10 foot bed-
53. " " " " " "
54. Dave Hertlein - Doyon - 3 ft. bed near Louden on the Yukon River.
55. Near Pickart mine site below Koyukuk on the Yukon River.
56. Blatchford mine site below Nulato, on the Yukon River.
57. Adolph Muller Prospect - Lears Pt., south of Kaltag
58. Ellens Camp (Ellen Peters, of Nulato) 16 miles below Nulato on the Yukon River.

59. Moving inland...Little Tonzona River, Talkeetna Quad; about halfway between Talkeetna and McGrath.

60. SHOW ON MAP - 277 ft. of section - with
61. 134 ft. of clean coal--Tertiary - Subbituminous 36-37 coal beds.

62. More familiar to all...Usibelli Mine at Healy
63. Should be producing 1.5 million tons per year
64. as a result on Korean Contract.

65. And Jarvis Creek field - under development - (big seam) owned by Delta Coal Company.

Moving southward...Just south of Cantwell...
66. in Broad Pass...Lignite. Used to be mined to supply the Alaska Railroad.

LIGHT ON -- MAP TALK

The Beluga and Yentna fields of the Susitna Lowland contain the largest recoverable coal reserves in southern Alaska. Coal-bearing rocks of the Tertiary Kenai group are scattered over some 6,000 mi^2. The coals are subbituminous. Seams up to 50 ft. thick are present. Identified resources for the Beluga and Yentna-Susitna fields are 10 Billion short tons, with Hypothetical resources of 30 billion short tons.

Diamond Alaska holds over 20,500 acres in State coal leases in the Beluga field, and Placer U.S. holds about 26,000 acres in leases.

Both companies have been exploring the possibility of synthetic fuel production. Mobile Oil holds 23,000 acres in the Yentan Basin.

The Matanuska field covers about ?? - The coal-bearing unit is the Chickaloon Formation...contains at least 30 coal beds up to 40 ft. thick 3 main areas--Wishbone Hill (Evan Jones), Chickaloon and Anthracite Ridge.

This is an up-graded coal---medium to low volatile bituminous - with some semi Anthracite and Anthracite found in the Anthracite Ridge district.

Between 1958 and 1960 over 20,000 tons of coal were produced here. Identified resources are 180 million short tons. Hypothetical Resources are 500 million short tons. Total past production has been 7.5 million tons.

SLIDES

67. This is the Chuitna Bed, Brown seam - 28 feet thick Susitna area.

68. Wishbone Hill - Matanuska field
69. Evan-Jones Mine - Wishbone Hill
70. Lone Ridge Mine - Beluga field
71. Waterfall seam - 36 feet thick - Beluga field

NOW - TO THE KENAI PENINSULA (MAP LIGHTS).

Much of the Kenai Peninsula is underlain by coal-bearing rocks. This is called the Kenai field--and it extends out under Cook Inlet -- and under Katchemak Bay. There are 3 coal-bearing formation --- The oldest, with the thickest Beds if the Tyonek. Next is the Beluga, then the Sterling. All are Tertiary in age. The coal is subbituminous.

Coal beds can be up to 20 ft. thick - but tend to be less. Identified resources are 320 Million short tons (onshore) and Hypothetical resources are 150 Billion tons. Much more lies under sea.

72. Here's a view of typical beach cliffs with coal beds near Homer.

NO SLIDE - SHOW PICTURES ON MAP MAT.

73 & 74. Down on the Alaska Peninsula --- Chignik
This is Bituminous in Rank.

75. Herendeen Bay and
76. Unga Island

77. Last ... The Bering River field. This field covers some 300 mi^2 in south-central Alaska. The coals are Tertiary -- but very deformed, and upgraded to High Volatile Bituminous to Anthracite. Coal beds up to 30 feet thick are present. Identified resources are 100 million tons, and Hypothetical Resources are 3.5 Billion T. The coal has been mined sporadically -- with about 100,000 tons being produced overall.

78. Chugach Natives and Korean-Alaskan Development Corp. working on development of the Bering River coalfield.

79. Some core from a drilling project at Bering River field.