

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Coal resources of the Fort Union Formation,
Rattlesnake Butte EMRIA study site,
Stark, Billings and Dunn Counties, North Dakota

By

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CONTENTS

	Page
ABSTRACT-----	1
INTRODUCTION-----	2
STRATIGRAPHY-----	5
COAL	
Origin-----	8
Classification-----	9
Rank of coal-----	9
Type of coal-----	13
Grade of coal-----	14
Chemical analysis of coal in the Rattlesnake Butte study site-----	14
ESTIMATION AND CLASSIFICATION OF COAL RESOURCES	
Tabulation of estimated coal resources-----	16
CHARACTERISTICS USED IN RESOURCE EVALUATION	
Density-----	31
Thickness of beds-----	31
Thickness of overburden-----	32
SUMMARY OF RESOURCES-----	32
REFERENCES CITED-----	33

ILLUSTRATIONS

Figure 1. Index map of the Rattlesnake Butte EMRIA study site, Stark, Billings and Dunn Counties, North Dakota-----	3
2. Generalized stratigraphic section, Rattlesnake Butte EMRIA study site, Dickinson coal field, North Dakota-----	6

3. Comparison (on moist, mineral-matter free basis) of heat of combustion and proximate analyses of coal of different ranks- 11

TABLES

Table 1. Legal description of land underlain by Federally owned coal in the Rattlesnake Butte EMRIA study site-----	4
2. Classification of coals by rank-----	12
3. Chemical analyses of 19 lignite samples from the Rattlesnake Butte EMRIA study site-----	15
4. Estimated identified coal resources of the Heart River (IV) lignite bed under 0-50 feet of overburden-----	17
5. Estimated identified coal resources of the Heart River (IV) lignite bed under 50-100 feet of overburden-----	18
6. Estimated identified coal resources of the Heart River (IV) lignite bed under more than 100 feet of overburden-----	19
7. Summary of estimated identified coal resources of the Heart River (IV) lignite bed -----	20
8. Estimated identified coal resources of the Fryburg (VIII) lignite bed under 0-50 feet of overburden-----	21
9. Estimated identified coal resources of the Fryburg (VIII) lignite bed under 50-100 feet of overburden-----	22
10. Estimated identified coal resources of the Fryburg (VIII) lignite bed under 100-150 feet of overburden-----	23
11. Estimated identified coal resources of the Fryburg (VIII) lignite bed under 150-200 feet of overburden-----	24

	Page
12. Estimated identified coal resources of the Fryburg (VIII) lignite bed under more than 200 feet of overburden-----	25
13. Summary of estimated identified coal resources of the Fryburg (VIII) lignite bed-----	26
14. Estimated identified coal resources of the HT Butte (XIII) lignite bed under more than 200 feet of overburden-----	27
15. Estimated identified coal resources of the HT Butte (XIII) rider lignite bed under more than 200 feet of overburden-----	28
16. Summary of estimated identified coal resources of the HT Butte (XIII) and HT Butte rider lignite beds-----	29

ABSTRACT

The Rattlesnake Butte EMRIA study site, an area of approximately 12,800 acres, is located in the Dickinson coal field in the central part of the Williston Basin, southwest North Dakota. This area contains surface-minable resources in three lignite beds that range in thickness from 1.4 to 18 feet, in the Tongue River and Sentinel Butte Members of the Fort Union Formation of Paleocene age.

Resources of lignite in the three beds total 484 million tons (439 million metric tons). Of this amount 26 percent or 128 million tons is in beds more than 10 feet thick that are under less than 200 feet of overburden. Measured resources total 55.7 million tons (50.5 million metric tons), indicated resources total 233 million tons (211 million metric tons), and inferred resources total 196 million tons (178 metric tons).

The apparent rank of the coal ranges from lignite A to lignite B. The average heat of combustion of 19 core samples from the site on the as-received basis is 5600 Btu/lb (3110 kcal/kg), average ash content is 10.6 percent, and average sulfur content is 1.0 percent.

INTRODUCTION

This report was prepared as a contribution to the study of the reclamation potential of the Rattlesnake Butte EMRIA study site in the Dickinson coal field in southwestern North Dakota (fig. 1). The area was selected by the U.S. Bureau of Land Management to be included in the EMRIA (Energy Minerals Rehabilitation Inventory and Analysis) program in order to evaluate the reclamation potential of sediments from the Tertiary Fort Union Formation in this part of the Williston Basin.

The Rattlesnake Butte EMRIA study site comprises about 12,800 acres of land underlain by Federally owned coal in an area of approximately 35,000 acres where the surface rights are under private ownership (table 1). The study site has its unusual configuration due to the "checkerboard" pattern of federally owned mineral rights (fig. 1) that dates back to the railroad grants made by Congress in 1862, where railroad corporations were to receive every alternate section of land in belts ranging in width from 20 to 40 miles on each side of the railroad (Bass, Smith and Horn, 1970). The area is located 12 miles (18 km) to the west of the city of Dickinson, North Dakota, within the Belfield, Belfield NE, Fairfield SE, New Hradec North and New Hradec South 7 1/2 minute quadrangles.

Coals of the Rattlesnake Butte study site were evaluated on the basis of drill-hole data and surface studies. During January and February of 1978 and January through April of 1979, the Water and Power Resources Service mapped the surface geology and drilled fifteen holes using continuous coring methods for the EMRIA program. Twenty-nine additional rotary holes were drilled during the 1978 and 1979 field seasons by the U.S. Geological Survey in the vicinity of the study site (fig. 1).

R. 99 W. R. 98 W.

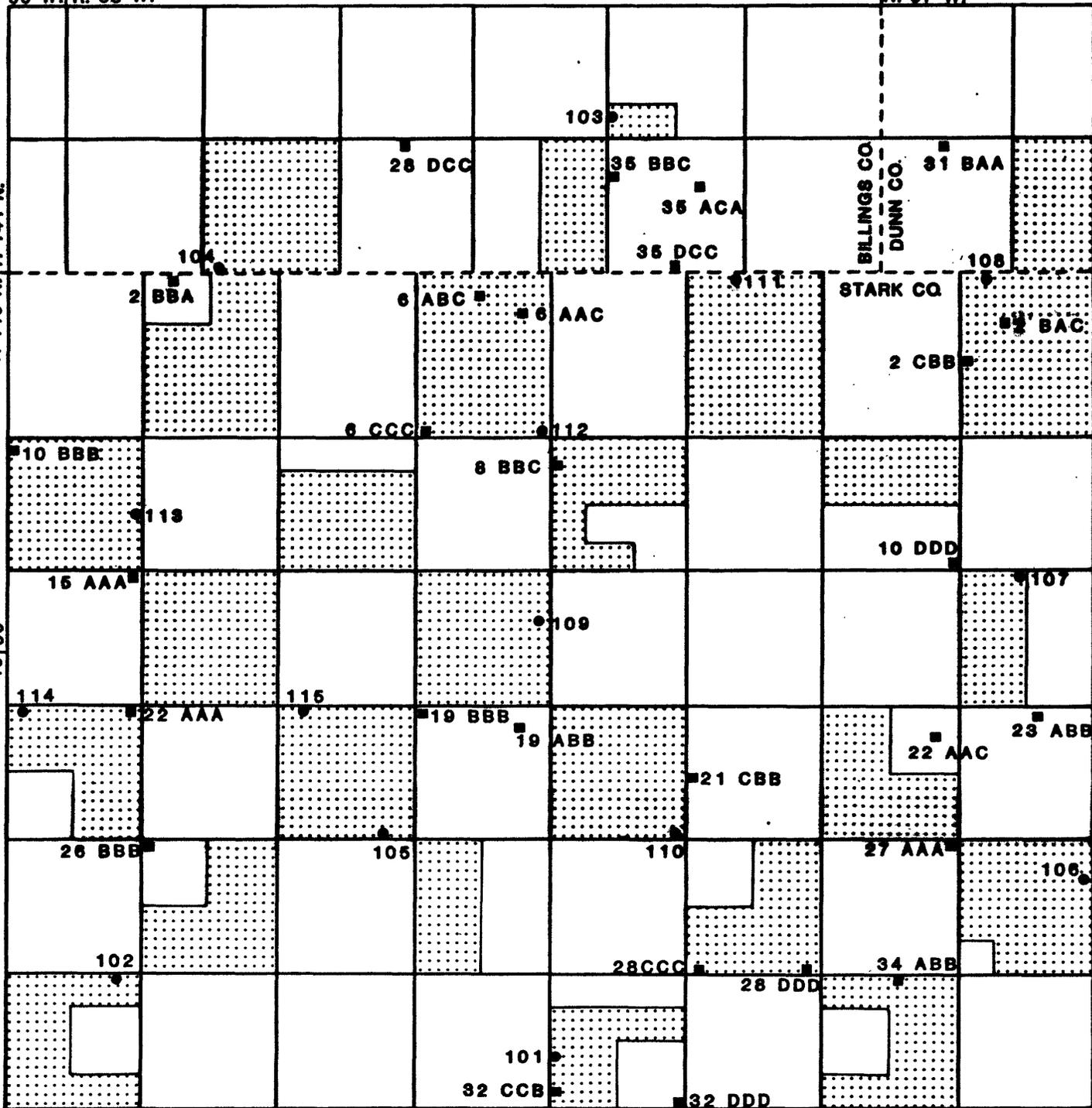
R. 97 W.

T. 140 N. T. 141 N.

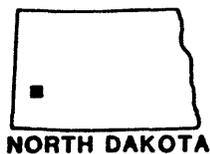
46° 55'

R. 99 W. R. 98 W.

103° 00'



EXPLANATION



LOCATION OF DRILL AND CORE HOLES

21 CBB ■ U.S. GEOLOGICAL SURVEY

110 ● WATER AND POWER RESOURCES



AREA OF EMRIA STUDY SITE

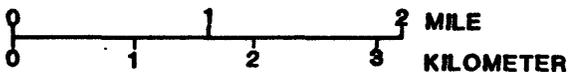


Fig. 1. --Index map of the Rattlesnake Butte EMRIA study site, Stark, Billings and Dunn Counties, North Dakota.

Table 1.--Legal description of land underlain by
Federally owned coal in the Rattlesnake Butte
EMRIA study site

T. 140 N., R. 98 W.
sec. 2
sec. 4
sec. 6
N $\frac{1}{2}$, W $\frac{1}{2}$ SW $\frac{1}{4}$, SE $\frac{1}{4}$ SW $\frac{1}{4}$, W $\frac{1}{2}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$, sec. 8
N $\frac{1}{2}$ sec. 10
W $\frac{1}{2}$ sec. 14
sec. 18
sec. 20
NW $\frac{1}{4}$, S $\frac{1}{2}$, sec. 22
N $\frac{1}{2}$, N $\frac{1}{2}$ SW $\frac{1}{4}$, SE $\frac{1}{4}$ SW $\frac{1}{4}$, SE $\frac{1}{4}$, sec. 26
NE $\frac{1}{4}$, S $\frac{1}{2}$, sec. 28
W $\frac{1}{2}$ sec. 30
S $\frac{1}{2}$ N $\frac{1}{2}$, SW $\frac{1}{4}$, sec. 32
NE $\frac{1}{4}$, N $\frac{1}{2}$ NW $\frac{1}{4}$, S $\frac{1}{2}$ SW $\frac{1}{4}$, SE $\frac{1}{4}$, sec. 34

T. 140 N., R. 99 W.
NE $\frac{1}{4}$, S $\frac{1}{2}$ S $\frac{1}{2}$ NW $\frac{1}{4}$, SW $\frac{1}{4}$, SE $\frac{1}{4}$, sec. 2
sec. 10
S $\frac{1}{2}$ N $\frac{1}{2}$, S $\frac{1}{2}$ m sec. 12
sec. 14
N $\frac{1}{2}$, SE $\frac{1}{4}$, sec. 22
sec. 24
NE $\frac{1}{4}$, S $\frac{1}{2}$, sec. 26
N $\frac{1}{2}$ N $\frac{1}{2}$, S $\frac{1}{2}$ NW $\frac{1}{4}$, N $\frac{1}{2}$ SW $\frac{1}{4}$, S $\frac{1}{2}$ S $\frac{1}{2}$, sec. 34

T. 141 N., R. 97 W.
W $\frac{1}{2}$ sec. 32

T. 141 N., R. 98 W.
S $\frac{1}{2}$ SW $\frac{1}{4}$ sec. 26
sec. 32
NE $\frac{1}{4}$, SE $\frac{1}{4}$, sec. 34

STRATIGRAPHY

The Paleocene Fort Union Formation contains the three lignite beds evaluated for the Rattlesnake Butte study site. In this area the Fort Union Formation consists of four members, in ascending order, the Cannonball, Ludlow, Tongue River, and Sentinel Butte (fig. 2).

The marine Cannonball Member consists of sandstone and shale. It intertongues with the overlying nonmarine Ludlow Member, which consists of sandstone, siltstone, shale, and lenticular lignite beds. The nonmarine Tongue River and Sentinel Butte Members both consist of sandstone, siltstone, shale, and one or more thick continuous lignite beds. The contact between the Tongue River Member and the Sentinel Butte Member is placed at the top of the HT Butte lignite bed. Only the Sentinel Butte Member crops out in the study site.

The three lignite beds of significant thickness in this area are: the HT Butte (or XIII) lignite bed in the Tongue River Member; the Fryburg (or VIII) lignite bed and the Heart River (or IV) lignite bed in the Sentinel Butte Member.

The stratigraphically lowest bed, the HT Butte bed, which was penetrated in 13 drill holes, ranges in thickness from 4 to 14 feet (1.2 to 4.3 m) at depths of 200 feet (61 m) or more. In six holes, in the eastern part of the study site, the bed splits into two beds. Interburden between the two beds ranges from 7 to 42 feet (2.1 to 12.8 m) thick. Where interburden thickness exceeds the upper lignite thickness, the upper coal is referred to as the HT Butte rider lignite bed. The lignite in the rider ranges from 2 to 5 feet (0.6 to 1.5 m) thick.

The Fryburg bed, which was penetrated in 41 drill holes, is 85 to 195 feet (26 to 59 meters) above the HT Butte bed, and ranges from 1.4 to 18 feet

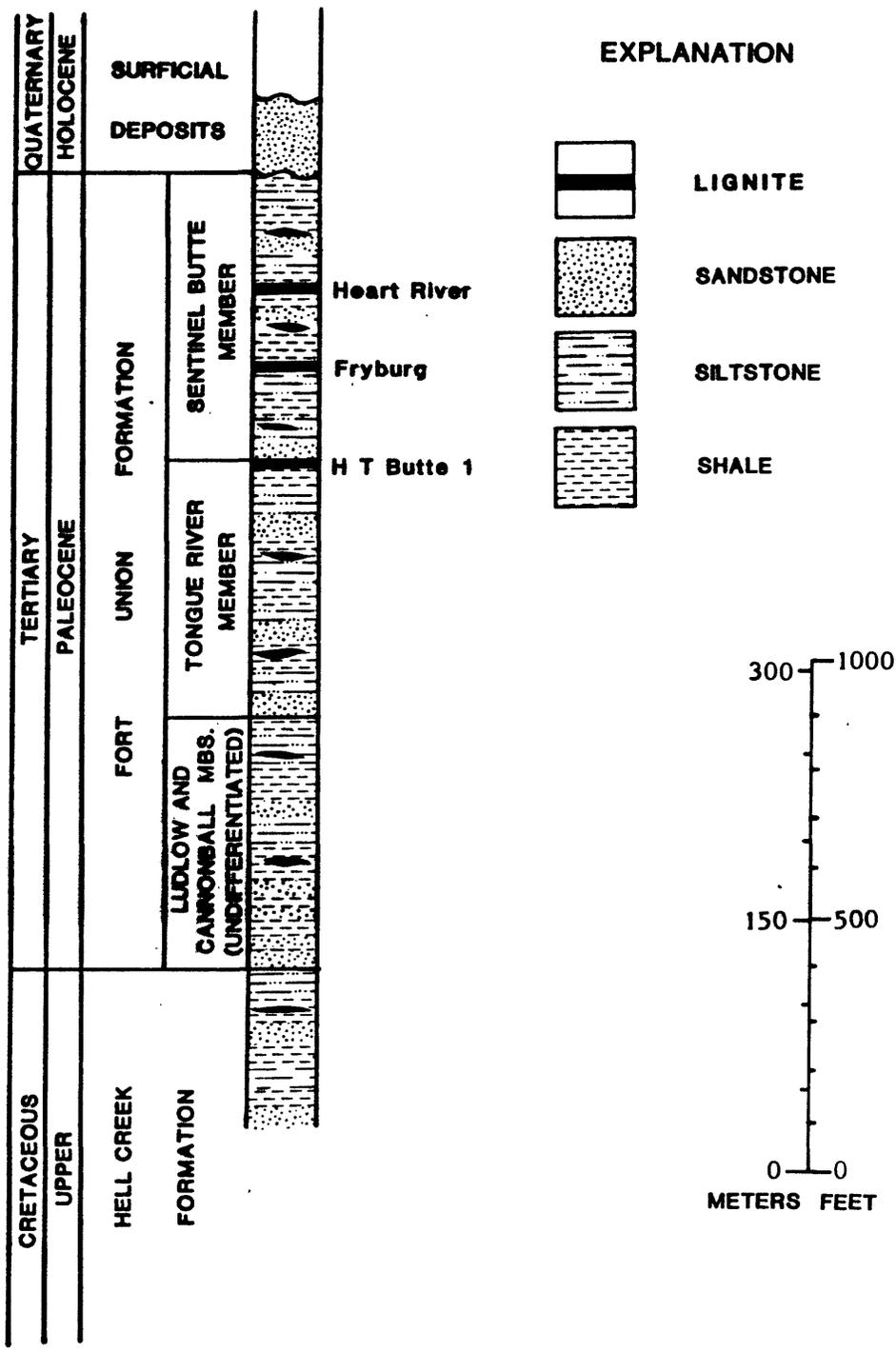


Fig. 2 --Generalized stratigraphic section, Rattlesnake Butte EMRIA study site, Dickinson coal field, North Dakota (modified from Menge, 1978)

(0.4 to 5.5 m) thick at depths of 35 to 198 feet (10.7 to 60.3 m). In the southeastern part of the study site, the bed contains a thin parting of rock. This lignite bed does not crop out anywhere in the study site.

The uppermost bed, the Heart River bed, which was penetrated in 33 drill holes, is 31 to 130 feet (9 to 40 m) above the Fryburg bed, and ranges from 4 to 12.5 ft (1.2 to 3.8 m) thick at depths of 13 to 139 feet (4 to 42.4 m). This lignite bed crops out in this area and in places has burned on outcrop, producing heat that has baked the overlying rocks into brittle, resistant, reddish rock called clinker. For the purposes of calculating coal resources, it is assumed that the contact between burned and unburned lignite is vertically below the contact between baked and unbaked rock.

COAL

Origin

Coal has been defined as "a readily combustible rock containing more than 50 percent by weight and more than 70 percent by volume of carbonaceous material, formed from compaction or induration of variously altered plant remains similar to those of peaty deposits. Differences in the kinds of plant materials (type), in degree of metamorphism (rank), and range of impurity (grade) are characteristics of the varieties of coal" (Schopf, 1966, p. 588). Inherent in the definition is the specification that the coal originated as a mixture of organic plant remains and inorganic mineral matter that accumulated in a manner similar to that in which modern-day peat deposits are formed. The peat underwent a long, complex process called "coalification", during which diverse physical and chemical changes occurred as the peat changed to coal and as the coal assumed the characteristics by which members of the series are differentiated from each other. The factors that affect the composition of coals have been summarized by Francis (1961, p. 2) as follows:

- 1) The mode of accumulation and burial of the plant debris forming the deposit.
- 2) The age of the deposits and their geographical distribution.
- 3) The structure of the coal-forming plants, particularly details of structure that affect chemical composition or resistance to decay.
- 4) The chemical composition of the coal-forming debris and its resistance to decay.
- 5) The nature and intensity of the plant-decaying agencies.
- 6) The subsequent geological history of the residual products of decay of the plant debris forming the deposits.

These factors, are discussed in greater detail by Moore (1940), Lowry

(1945), Tomkeieff (1954), Francis (1961), and Lowry (1963).

Classification

Coals are classified in many ways (Tomkeieff, 1954, p. 9; Moore, 1940, p. 113; Francis, 1961, p. 361), but the classification by rank, that is, by degree of metamorphism in the progressive series that begins with peat and ends with graphocite (Schopf, 1966), is the most commonly used system. Classification by types of plant materials is commonly used as a descriptive adjunct to rank classification when sufficient megascopic and microscopic information is available, and classification by type and quantity of impurities (grade) is also frequently used when utilization of the coal is being considered. Other categorizations are possible and are commonly employed in discussion of coal resources. Factors such as density of the coal, thickness and areal extent of individual coal beds, and the thickness of overburden are generally considered.

Rank of coal

The position of a coal within the metamorphic series, which begins with peat and ends with graphocite, is dependent upon temperature and pressure to which the coal has been subjected and the duration of time of subjection. Because it is, by definition, largely derived from plant material, coal is mostly composed of carbon, hydrogen, and oxygen along with smaller quantities of nitrogen, sulfur, and other elements. The increase in rank of coal as it undergoes progressive metamorphism is indicated by changes in the proportions of the coal constituents; for example, the higher rank coals have more carbon and less hydrogen than the lower rank coals.

Two standardized forms of coal analyses--the proximate analysis and the ultimate analysis--are generally used, although sometimes only the less complicated and less expensive proximate analysis is made. The analyses are described as follows (U.S. Bureau of Mines, 1965, p. 121-122):

The proximate analysis of coal involves the determination of four constituents: (1) water, called moisture; (2) mineral impurity, called ash, left when the coal is completely burned; (3) volatile matter, consisting of gases or vapors driven out when coal is heated to certain temperatures; and (4) fixed carbon, the solid or cokelike residue that burns at higher temperatures after volatile matter has been driven off. Ultimate analysis involves the determination of carbon and hydrogen as found in the gaseous products of combustion, the determination of sulfur, nitrogen, and ash in the material as a whole, and the estimation of oxygen by difference.

Most coals are burned to produce heat energy, and so the heat of combustion of the coal is an important property. The heat of combustion (calorific value) is commonly expressed in British thermal units (Btu) per pound: one Btu is the amount of heat required to raise the temperature of 1 pound of water 1 degree fahrenheit (in the metric system, heat of combustion is expressed in kilogram-calories per kilogram). Additional tests are sometimes made, particularly to determine the caking, coking, and other properties, such as tar yield, which affect classification or utilization.

Figure 3 compares, in histogram form, the heat of combustion and moisture, volatile matter, and fixed carbon contents of coals of different ranks.

Various schemes for classifying coals by rank have been proposed and used, but the most commonly employed is that entitled, "Standard specifications for classification of coals by rank," adopted by the American Society for Testing and Materials (1977) (table 2).

The ASTM classification system differentiates coals into classes and groups on the basis of mineral-matter-free fixed carbon or volatile matter and the heating value, supplemented by determination of agglomerating (caking) characteristics. As pointed out by the ASTM (1977, p. 216), a standard rank determination cannot be made unless the samples were obtained in accordance

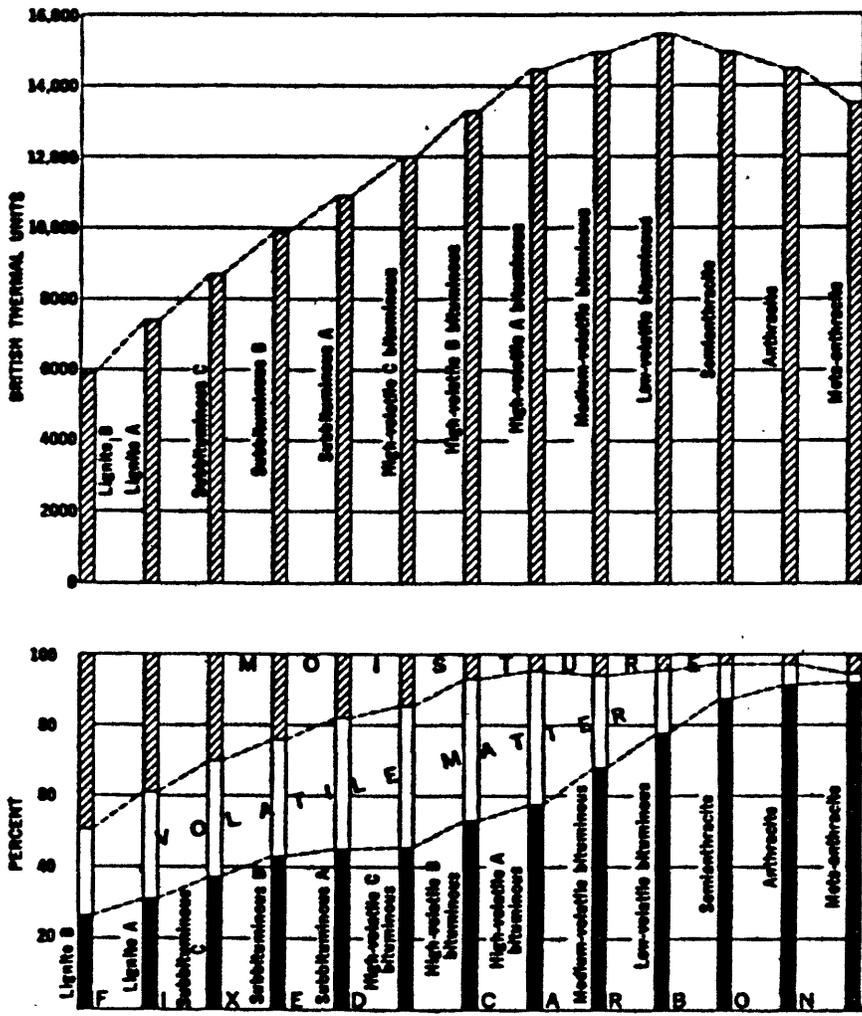


Fig. 4.--Comparison (on moist, mineral-matter-free basis) of heat of combustion proximate analyses of different ranks (from Averitt, 1975, p. 17)

Table 2.--Classification of coals by rank¹

[American Society for Testing and Materials Standard D388-66 (Reapproved 1972); 1 Btu equals 0.252 kilogram-calories]

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, Mineral-Matter-Free Basis)		Agglomerating Character
		Equal or Greater Than	Less Than	Greater Than	Equal or Less Than	Equal or Greater Than	Less Than	
I. Anthracite	1. Meta-anthracite	98	---	---	2	---	---	nonagglomerating
	2. Anthracite	92	98	2	8	---	---	
	3. Semianthracite ³	86	92	8	14	---	---	
II. Bituminous	1. Low volatile bituminous coal	78	86	14	22	---	---	commonly agglomerating ⁵
	2. Medium volatile bituminous coal	69	78	22	31	---	---	
	3. High volatile A bituminous coal	---	69	31	---	14 000 ⁴	---	
	4. High volatile B bituminous coal	---	---	---	---	13 000 ⁴	14 000	
	5. High volatile C bituminous coal	---	---	---	---	11 500	13 000	
III. Subbituminous	1. Subbituminous A coal	---	---	---	---	10 500	11 500	agglomerating
	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	nonagglomerating
	2. Lignite B	---	---	---	---	---	6 300	

¹This 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.

²Moist refers to coal containing its natural inherent moisture but not including visible water on the surface of the coal.

³If agglomerating, classify in low-volatile group of the bituminous class.

⁴Coals 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.

⁵It is recognized that there may be nonagglomerating varieties in these groups of the bituminous class, and there are notable exceptions in high volatile C bituminous group.

with standardized sampling procedures (Schopf, 1960). However, nonstandard samples may be used for comparative purposes through determinations designated as "apparent rank." For this study area 19 samples analyzed by the U.S. Department of Energy show heat of combustion values that range from 4570 to 6220 Btu/lb on the as-received basis. Based on these data the apparent rank of the coal ranges from lignite A to lignite B.

Type of coal

Classification of coals by type--that is, according to the types of plant materials present--takes many forms, such as the "rational analysis" of Francis (1961) or the semicommercial "type" classification commonly used in the coal fields of the eastern United States (U.S. Bureau of Mines, 1965, p. 123). However, most of the type classifications are based on the same, or similar, gross distinctions in plant material as those used by Tomkeieff (1954, Table II and p. 9), who divided the coals into three series: humic coals, humic-sapropelic coals, and sapropelic coals, based upon the nature of the original plant materials. The humic coals are largely composed of the remains of the woody parts of plants and the sapropelic coals are largely composed of the more resistant waxy, fatty, and resinous parts of plants, such as cell walls, spore-coatings, pollen, resin particles, and coals composed mainly of algal material. Most coals fall into the humic series, with some coals being a mixture of humic and sapropelic elements and, therefore, falling into the humic-sapropelic series. The sapropelic series is quantitatively insignificant and when found is commonly regarded as an organic curiosity. In common with most of the U.S. coals, those from the Rattlesnake Butte EMRIA study site fall largely in the humic series.

Grade of coal

Classification of coal by grade, or quality, is based largely on the content of ash, sulfur, and other constituents that adversely affect utilization.

The ash content of 19 lignite samples from the Rattlesnake Butte study site, on the as-received basis, ranges from 5.5 to 25.9 percent, averaging 10.6 percent; and the sulfur content ranges from 0.3 to 3.0 percent, averaging 1.0 percent (table 3). For comparison, the ash content of 32 lignite samples from Dunn County, North Dakota (Hatch and Affolter, 1978), ranges from 3.7 to 19.8 percent, averaging 8.4 percent; and the sulfur content ranges from 0.2 to 2.6 percent, averaging 1.1 percent.

Chemical analysis of coal in the Rattlesnake Butte study site

Proximate analysis, sulfur content, and heat content on 19 lignite samples (table 3) were provided by chemists from the Coal Analysis Section (John Puskas, Acting Chief), U.S. Department of Energy, Pittsburgh, Pa., whose contribution is gratefully acknowledged.

Seven samples taken from the Heart River lignite bed in the Rattlesnake Butte study site have ash contents that range from 5.5 to 9.1 percent, averaging 6.4 percent, and have sulfur contents that range from 0.4 to 2.6 percent, averaging 0.8 percent. Nine samples taken from the Fryburg lignite bed in the Rattlesnake Butte study site have ash contents that range from 8.9 to 17.2 percent, averaging 12.2 percent, and have sulfur contents that range from 0.3 to 3.0 percent, averaging 1.1 percent. The HT Butte lignite bed was not sampled in this area. A more detailed breakdown of analyses of the Heart River and Fryburg lignite beds is in table 3. Compared to 488 samples of other U.S. coal (Swanson and others, 1976), lignite of the Heart River bed has relatively high moisture content, low sulfur content, low heat of

Table 3.--Chemical analyses of 19 lignite samples from the Rattlesnake Butte EMRIA study site

[All analyses are in percent except Btu/lb; to convert feet to meters multiply by 0.305; to convert Btu/lb to Kcal/kg multiply by 0.556.]

Laboratory number	Coal bed name	Drill hole number	Depth interval feet	Proximate			Ultimate		Btu/lb (as-received)
				Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	
K99744	Heart River	112-1	34.3- 38.9	42.6	27.0	24.9	5.5	0.4	6216
K99745	Fryburg	112-2	138.5-145.0	40.9	22.3	23.8	13.0	.3	5316
K99746	Heart River	111-1	20.3- 28.7	45.0	23.2	26.0	5.8	.5	5738
K99747	Local	111-2	125.9-129.7	35.7	20.6	17.8	25.9	.8	4566
K99748	Fryburg	111-3	159.0-165.9	40.7	24.3	25.4	9.6	1.3	5911
K99749	Local	109-1	25.8- 29.5	40.4	23.9	21.5	14.2	2.6	5292
K99750	Heart River	109-2	57.5- 68.5	45.7	23.6	24.6	6.1	.5	5708
K99751	Fryburg	109-3	116.1-119.7	43.9	23.0	24.1	9.0	.9	5607
K99752	Heart River	107-1	138.7-149.3	45.1	23.5	25.7	5.7	.5	5825
K99753	Fryburg	107-2	181.1-183.5	39.2	21.8	21.8	17.2	1.1	5199
K99754	Fryburg	107-3	187.2-194.7	41.5	21.1	23.3	14.1	3.0	5210
K99755	Heart River	110-1	64.8- 74.8	44.8	24.0	25.2	6.0	.8	5832
K99756	Fryburg	110-2	136.2-149.0	41.5	22.7	23.8	12.0	.7	5505
K99757	Fryburg	114-1	90.5- 94.6	39.0	23.6	22.6	14.8	1.7	5508
K99758	Heart River	106-1	90.5-108.2	43.7	23.1	26.3	6.9	.6	5845
K99759	Fryburg	106-2	198.7-208.2	39.6	22.9	26.0	11.5	.4	5790
K99760	Heart River	102-1	48.2- 53.2	41.1	25.3	24.5	9.1	2.6	5749
K99761	Fryburg	102-2	139.5-149.6	42.7	24.5	23.9	8.9	.8	5725
K99762	Local	102-3	159.9-164.3	43.1	24.3	26.1	6.5	.4	5903
Heart River range				41.1- 47.7	23.1- 27.0	24.5- 26.3	5.5- 9.1	0.4- 2.6	5708- 6216
Heart River average				44.3	24.2	25.3	6.4	.8	5845
Fryburg range				39.0- 43.9	21.1- 24.5	21.8- 26.0	8.9- 17.2	.3- 3.0	5199- 5911
Fryburg average				41.0	22.9	23.9	12.2	1.1	5530
Range of 19 samples				35.7- 45.7	20.6- 27.0	17.8- 26.3	5.5- 25.9	0.3- 3.0	4566- 6216
Average of 19 samples				41.9	23.4	24.1	10.6	1.0	5602

combustion, and low ash content; when applying the same comparison to the lignite of the Fryburg bed, the Fryburg has relatively high moisture content, low sulfur content, a low heat of combustion, and a slightly higher ash content.

ESTIMATION AND CLASSIFICATION OF COAL RESOURCES

Coal resource estimates have been prepared for the Fort Union coal within the Rattlesnake Butte EMRIA study site using standard procedures, definitions, and criteria established by the U.S. Bureau of Mines and U.S. Geological Survey (1976) for making coal resource appraisals in the United States. The term "coal resources" as used in this report means the estimated quantity of coal in the ground in such form that economic extraction is currently or potentially feasible.

Tabulation of estimated coal resources

Tables 4-16 summarize the estimated lignite resources of the Rattlesnake Butte EMRIA study site. The resources in the study site are classed as measured, indicated, and inferred according to the degree of geologic assurance of the estimate.

Table 4.--Estimated identified coal resources of the Heart River (IV) lignite bed under 0-50 feet of overburden, Sentinel Butte Member, Fort Union Formation, Rattlesnake Butte EMRIA study site, Stark, Billings and Dunn Counties, North Dakota as of August 1, 1980

[Leaders (---) indicate not present. In millions of short tons. 1 foot = 0.305 meters; 1 short ton = 0.907 metric ton; numbers are rounded to three significant figures.]

Location	Measured			Indicated			Inferred			Total
	Thickness of coal in feet			Thickness of coal in feet			Thickness of coal in feet			
	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	
T. 140 N., R. 98 W.										
sec. 2	---	0.075	---	---	---	---	---	---	---	0.075
4	---	1.37	---	---	4.42	---	---	0.329	---	6.12
6	0.461	---	1.91	---	2.67	0.179	---	---	---	5.22
8	---	.912	---	---	4.00	.305	---	---	---	5.22
10	---	---	---	---	---	---	---	---	---	---
14	---	---	---	---	---	---	---	---	---	---
18	---	---	1.43	---	---	2.02	---	---	---	3.45
20	---	.642	---	---	3.86	.263	---	---	.401	5.17
22	---	.041	---	---	---	2.53	---	---	1.34	3.91
26	---	.085	---	---	3.56	---	---	.520	---	4.16
28	---	---	---	---	1.03	.212	---	2.36	---	3.60
30	---	---	---	---	---	---	---	---	---	---
32	---	.804	---	---	1.21	---	---	---	---	2.01
34	---	.628	---	---	.124	---	---	---	---	.752
Township total	0.461	4.56	3.34	---	20.9	5.51	---	3.21	1.74	39.7
T. 140 N., R. 99 W.										
sec. 2	---	0.050	---	---	3.38	---	---	3.14	---	6.57
10	---	.962	---	---	4.01	---	---	.470	---	5.44
12	---	---	---	---	0.107	---	---	.095	---	0.202
14	---	---	---	---	1.50	---	---	1.06	---	2.56
22	0.418	---	---	0.493	---	---	---	---	---	.911
24	---	---	---	---	---	---	---	---	---	---
26	---	---	0.133	.165	2.28	---	0.904	1.23	---	4.71
34	---	---	1.15	---	---	1.85	---	---	2.95	5.95
Township total	0.418	1.01	1.28	0.658	11.3	1.85	0.904	6.00	2.95	26.4
T. 141 N., R. 97 W.										
sec. 32	---	---	---	---	---	1.26	---	---	2.67	3.93
Township total	---	---	---	---	---	1.26	---	---	2.67	3.93
T. 141 N., R. 98 W.										
sec. 26	---	---	0.198	---	---	0.594	---	---	---	0.792
32	---	---	---	---	4.17	.809	---	0.283	3.21	8.47
34	---	0.702	---	---	.544	1.48	---	---	---	2.73
Township total	---	0.702	0.198	---	4.71	2.88	---	0.283	3.21	12.0
Total	0.879	6.27	4.82	0.658	36.9	11.5	0.904	9.49	10.6	82.0

Table 5.--Estimated identified coal resources of the Heart River (IV) lignite bed under 50-100 feet of overburden, Sentinel Butte Member, Fort Union Formation, Rattlesnake Butte EMRIA study site, Stark, Billings and Dunn Counties, North Dakota as of August 1, 1980

[Leaders (---) indicate not present. In millions of short tons. 1 foot = 0.305 meters; 1 short ton = 0.907 metric ton; numbers are rounded to three significant figures.]

Location	Measured			Indicated			Inferred			Total
	Thickness of coal in feet			Thickness of coal in feet			Thickness of coal in feet			
	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	
T. 140 N., R. 98 W.										
sec. 2	---	2.61	0.260	---	0.123	7.77	---	---	0.648	11.4
4	---	---	---	---	0.009	---	---	3.25	---	3.26
6	---	1.01	.546	---	2.58	---	---	---	---	4.14
8	---	---	---	---	.915	---	---	.499	---	1.41
10	---	---	---	---	1.22	---	---	1.60	---	2.82
14	---	.685	.031	---	2.70	---	---	---	---	3.42
18	---	---	.073	---	---	---	---	---	---	.073
20	---	.223	.609	---	.134	.577	---	---	---	1.54
22	---	.477	---	---	---	2.57	---	---	1.14	4.19
26	---	.368	1.44	---	3.42	---	---	---	---	5.23
28	---	---	---	---	.504	---	---	1.18	---	1.68
30	---	---	---	---	---	---	---	---	---	---
32	---	.011	---	---	---	---	---	---	---	.011
34	---	---	---	---	---	---	---	---	---	---
Township total	---	5.38	2.96	---	11.6	10.9	---	6.53	1.79	39.2
T. 140 N., R. 99 W.										
sec. 2	---	0.409	---	---	0.612	---	---	0.169	---	1.19
10	---	.418	---	---	2.85	---	---	.044	---	3.31
12	---	---	---	---	---	---	---	---	---	---
14	---	---	---	---	---	---	---	.045	---	0.045
22	0.144	---	---	0.368	.421	---	---	---	---	.933
24	---	---	---	---	---	---	---	---	---	---
26	---	---	---	.233	.024	---	0.157	---	---	.414
34	---	---	---	---	---	---	---	---	2.28	2.28
Township total	0.144	0.827	---	0.601	3.91	---	0.157	0.258	2.28	8.18
T. 141 N., R. 97 W.										
sec. 32	---	---	---	---	---	1.57	---	---	0.393	1.96
Township total	---	---	---	---	---	1.57	---	---	0.393	1.96
T. 141 N., R. 98 W.										
sec. 26	---	---	0.292	---	---	---	---	---	---	0.292
32	---	0.853	---	---	0.622	---	---	---	---	1.47
34	---	---	---	---	---	---	---	---	---	---
Township total	---	0.853	0.292	---	0.622	---	---	---	---	1.77
Total	0.144	7.06	3.25	0.601	16.1	12.5	0.157	6.79	4.46	51.1

Table 6.--Estimated identified coal resources of the Heart River (IV) lignite bed under >100 feet of overburden, Sentinel Butte Member, Fort Union Formation, Rattlesnake Butte EMRIA study site, Stark, Billings and Dunn Counties, North Dakota as of August 1, 1980

[Leaders (---) indicate not present. In millions of short tons. 1 foot = 0.305 meters; 1 short ton = 0.907 metric ton. a, includes .050 million tons with >150' overburden; b, includes 0.30 million tons with >150' overburden; numbers are rounded to three significant figures.]

Location	Measured			Indicated			Inferred			Total
	Thickness of coal in feet			Thickness of coal in feet			Thickness of coal in feet			
	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	
T. 140 N., R. 98 W.										
sec. 2	---	0.892	---	---	0.269	0.552	---	---	0.718	2.43
4	---	---	---	---	---	---	---	0.125	---	0.125
6	---	---	---	---	---	---	---	---	---	---
8	---	---	---	---	---	---	---	---	---	---
10	---	---	---	---	.367	---	---	^a 1.22	---	1.59
14	---	.787	---	---	^b .876	---	---	---	---	1.66
18	---	---	---	---	---	---	---	---	---	---
20	---	---	---	---	---	---	---	---	---	---
22	---	---	---	---	---	.179	---	---	---	.179
26	---	---	---	---	---	---	---	---	---	---
28	---	---	---	---	.035	---	---	---	---	.035
30	---	---	---	---	---	---	---	---	---	---
32	---	---	---	---	---	---	---	---	---	---
34	---	---	---	---	---	---	---	---	---	---
Township total	---	1.68	---	---	1.55	.731	---	1.34	0.718	6.02
T. 140 N., R. 99 W.										
sec. 2	---	---	---	---	---	---	---	---	---	---
10	---	0.322	---	---	---	---	---	---	---	0.322
12	---	---	---	---	---	---	---	---	---	---
14	---	---	---	---	---	---	---	---	---	---
22	---	---	---	.009	---	---	---	---	---	.009
24	---	---	---	---	---	---	---	---	---	---
26	---	---	---	.030	---	---	---	---	---	.030
34	---	---	---	---	---	---	---	---	---	---
Township total	---	0.322	---	0.039	---	---	---	---	---	0.361
T. 141 N., R. 97 W.										
sec. 32	---	---	---	---	---	---	---	---	---	---
Township total	---	---	---	---	---	---	---	---	---	---
T. 141 N., R. 98 W.										
sec. 26	---	---	---	---	---	---	---	---	---	---
32	---	0.024	---	---	---	---	---	---	---	0.024
34	---	---	---	---	---	---	---	---	---	---
Township total	---	0.024	---	---	---	---	---	---	---	0.024
Total	---	2.03	---	0.039	1.55	0.731	---	1.34	0.718	6.41

Table 7.--Summary of estimated identified coal resources of the Heart River (1V) lignite bed, Sentinel Butte Member, Fort Union Formation, Rattlesnake Butte EMRIA study site, as of August 1, 1980

[Leaders (---) indicate not present. In millions of short tons. 1 foot = 0.305 meters. 1 short ton = 0.907 metric ton; numbers are rounded to three significant figures.]

	T. 140 N. R. 98 W.	T. 140 N. R. 99 W.	T. 141 N. R. 97 W.	T. 141 N. R. 98 W.	Total
Coal bed 2 1/2 to 5 feet thick					
Measured resources	0.461	0.562	---	---	1.02
Indicated resources	---	1.30	---	---	1.30
Inferred resources	---	1.061	---	---	1.06
Total	0.461	2.92	---	---	3.38
Coal bed 5-10 feet thick					
Measured resources	11.6	2.16	---	1.58	15.3
Indicated resources	34.0	15.2	---	5.33	54.5
Inferred resources	11.1	6.26	---	.283	17.6
Total	56.7	23.6	---	7.19	87.5
Coal bed >10 feet thick					
Measured resources	6.30	1.28	---	0.490	8.07
Indicated resources	17.1	1.85	2.83	2.88	24.7
Inferred resources	4.25	5.23	3.06	3.21	15.7
Total	27.6	8.36	5.89	6.58	48.5
Total identified resources	84.8	34.9	5.89	13.8	139.

Table 8.--Estimated identified coal resources of the Fryburg (VIII) lignite bed under 0-50 feet of overburden, Sentinel Butte Member, Fort Union Formation, Rattlesnake Butte EMRIA study site, Stark, Billings and Dunn Counties, North Dakota as of August 1, 1980

[Leaders (---) indicate not present. In millions of short tons. 1 foot = 0.305 meters; 1 short ton = 0.907 metric ton; numbers are rounded to three significant figures.]

Location	Measured			Indicated			Inferred			Total
	Thickness of coal in feet			Thickness of coal in feet			Thickness of coal in feet			
	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	
T. 140 N., R. 98 W.										
sec. 2	---	---	---	---	---	---	---	---	---	---
4	---	---	---	---	---	---	---	---	---	---
6	---	---	---	---	---	---	---	---	---	---
8	---	---	---	---	---	---	---	---	---	---
10	---	---	---	---	---	---	---	---	---	---
14	---	---	---	---	---	---	---	---	---	---
18	0.022	---	---	1.11	---	---	0.110	---	---	1.24
20	---	---	---	---	---	---	---	---	---	---
22	---	---	---	---	---	---	---	---	---	---
26	---	---	---	---	---	---	---	---	---	---
28	---	---	0.340	---	---	---	---	---	---	0.340
30	---	0.175	---	---	---	3.22	---	---	1.53	4.93
32	---	---	---	---	---	.406	---	---	---	.406
34	---	---	---	---	1.60	---	---	0.103	---	1.70
Subtotal	0.022	0.175	0.340	1.11	1.60	3.63	0.110	0.103	1.53	8.62
T. 140 N., R. 99 W.										
sec. 2	---	---	---	---	---	---	---	---	---	---
10	---	---	---	---	---	---	---	---	---	---
12	---	---	---	0.153	---	---	0.009	---	---	0.162
14	0.083	---	---	0.588	---	---	---	---	---	.671
22	---	---	---	---	---	---	---	---	---	---
24	.379	.892	---	---	4.07	---	---	0.120	---	5.46
26	---	---	---	---	---	---	---	---	---	---
34	---	---	---	---	---	---	---	---	---	---
Subtotal	0.462	0.892	---	0.741	4.07	---	0.009	0.120	---	6.29
T. 141 N., R. 97 W.										
sec. 32	---	---	---	---	---	---	---	---	---	---
Subtotal	---	---	---	---	---	---	---	---	---	---
T. 141 N., R. 98 W.										
sec. 26	---	---	---	---	---	---	---	---	---	---
32	---	---	---	---	---	---	---	---	---	---
34	---	---	---	---	---	---	---	---	---	---
Subtotal	---	---	---	---	---	---	---	---	---	---
Total	0.484	1.07	0.340	1.85	5.67	3.63	0.119	0.223	1.53	14.9

Table 9.--Estimated identified coal resources of the Fryburg (VIII) lignite bed under 50-100 feet of overburden, Sentinel Butte Member, Fort Union Formation, Rattlesnake Butte EMRIA study site, Stark, Billings and Dunn Counties, North Dakota as of August 1, 1980

[Leaders (---) indicate not present. In millions of short tons. 1 foot = 0.305 meters; 1 short ton = 0.907 metric ton; numbers are rounded to three significant figures.]

Location	Measured			Indicated			Inferred			Total
	Thickness of coal in feet			Thickness of coal in feet			Thickness of coal in feet			
	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	
T. 140 N., R. 98 W.										
sec. 2	---	---	---	---	---	---	---	---	---	---
4	---	---	---	---	---	---	---	---	---	---
6	---	---	---	---	---	---	---	---	---	---
8	0.014	---	---	1.07	---	---	---	---	---	1.08
10	---	---	---	---	---	---	---	---	---	---
14	---	---	---	---	---	---	---	---	---	---
18	.765	---	---	1.06	---	---	---	---	---	1.82
20	---	0.059	---	---	3.46	1.01	---	---	0.631	5.16
22	---	---	---	---	---	1.49	---	---	.380	1.870
26	---	---	---	---	0.106	1.23	---	0.337	---	1.67
28	---	---	1.28	---	---	3.49	---	---	---	4.77
30	---	---	---	---	---	0.291	---	---	1.68	1.97
32	---	---	2.30	---	---	4.51	---	---	---	6.80
34	---	---	1.79	---	1.25	0.561	---	---	2.56	6.16
Subtotal	0.779	0.059	5.37	2.13	4.82	12.6	---	0.337	5.25	31.3
T. 140 N., R. 99 W.										
sec. 2	---	---	---	0.231	---	---	0.081	---	---	0.312
10	---	---	---	---	---	---	.071	---	---	.071
12	---	---	---	.358	---	---	---	---	---	.358
14	0.081	---	---	.441	---	---	---	---	---	.522
22	.539	---	---	---	1.60	---	---	---	---	2.14
24	.013	---	---	.535	.370	---	---	0.124	---	1.04
26	---	---	0.017	---	---	2.02	---	.279	2.08	4.40
34	---	---	.089	---	---	1.249	---	---	0.751	2.09
Subtotal	0.633	---	0.106	1.56	1.97	3.27	0.152	0.403	2.83	10.9
T. 141 N., R. 97 W.										
sec. 32	---	---	---	---	---	---	---	---	---	---
Subtotal	---	---	---	---	---	---	---	---	---	---
T. 141 N., R. 97 W.										
sec. 26	---	---	---	---	---	---	---	---	---	---
32	---	---	---	0.154	---	---	1.32	---	---	1.47
34	0.031	---	---	.198	---	---	---	---	---	0.229
Subtotal	0.031	---	---	0.352	---	---	1.32	---	---	1.70
Total	1.44	0.059	5.48	4.04	6.79	15.9	1.47	0.740	8.08	44.0

Table 10.--Estimated identified coal resources of the Fryburg (VIII) lignite bed under 100-150 feet of overburden, Sentinel Butte Member, Fort Union Formation, Rattlesnake Butte EMRIA study site, Stark, Billings and Dunn Counties, North Dakota as of August 1, 1980

[Leaders (---) indicate not present. In millions of short tons. 1 foot = 0.305 meters; 1 short ton = 0.907 metric ton; numbers are rounded to three significant figures.]

Location	Measured			Indicated			Inferred			Total
	Thickness of coal in feet			Thickness of coal in feet			Thickness of coal in feet			
	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	
T. 140 N., R. 98 W.										
sec. 2	---	0.887	---	---	0.543	0.787	---	---	---	2.22
4	---	.784	---	---	3.15	---	---	0.407	---	4.34
6	---	.376	---	0.519	---	---	0.086	---	---	0.981
8	0.500	---	---	.056	1.56	---	---	.153	---	2.27
10	---	---	---	---	0.043	.522	---	.337	0.054	.956
14	---	.459	0.279	---	---	3.65	---	---	---	4.39
18	.082	---	---	---	---	---	---	---	---	.082
20	---	---	1.62	---	1.44	1.15	---	---	---	4.21
22	---	---	.656	---	---	5.56	---	---	1.75	7.97
26	---	---	.564	---	2.50	3.17	---	.298	---	6.53
28	---	---	.127	---	---	3.00	---	---	.958	4.09
30	---	---	---	---	---	---	---	---	---	---
32	---	---	.997	---	---	.829	---	---	---	1.83
34	---	.006	.085	---	---	---	---	---	---	.091
Subtotal	0.582	2.51	4.33	0.575	9.24	18.7	0.086	1.19	2.76	40.0
T. 140 N., R. 99 W.										
sec. 2	0.020	---	---	0.861	---	---	0.139	---	---	1.02
10	---	---	---	.016	---	---	.030	---	---	0.046
12	---	---	---	.008	---	---	---	---	---	.008
14	---	---	---	---	---	---	---	---	---	---
22	.116	0.361	---	.044	1.75	---	---	---	---	2.27
24	---	---	---	---	---	---	---	---	---	---
26	---	---	0.128	---	.412	1.30	---	1.01	0.701	3.55
34	---	---	1.08	---	---	1.97	---	---	2.60	5.65
Subtotal	0.136	0.361	1.21	0.929	2.163	3.27	0.169	1.01	3.30	12.5
T. 141 N., R. 97 W.										
sec. 32	---	---	---	---	0.284	---	---	0.305	---	0.589
Subtotal	---	---	---	---	0.284	---	---	0.305	---	0.589
T. 141 N., R. 98 W.										
sec. 26	0.134	---	---	0.200	---	---	---	---	---	0.334
32	---	---	---	.992	---	---	1.44	---	---	2.43
34	.233	---	---	.582	---	---	0.106	---	---	.921
Subtotal	0.367	---	---	1.77	---	---	1.55	---	---	3.69
Total	1.08	2.87	5.54	3.27	11.7	22.0	1.80	2.51	6.06	56.8

Table 11.--Estimated identified coal resources of the Fryburg (VIII) lignite bed under 150-200 feet of overburden, Sentinel Butte Member, Fort Union Formation, Rattlesnake Butte EMRIA study site, Stark, Billings and Dunn Counties, North Dakota as of August 1, 1980

[Leaders (---) indicate not present. In millions of short tons. 1 foot = 0.305 meters; 1 short ton = 0.907 metric ton; numbers are rounded to three significant figures.]

Location	Measured			Indicated			Inferred			Total
	Thickness of coal in feet			Thickness of coal in feet			Thickness of coal in feet			
	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	
T. 140 N., R. 98 W.										
sec. 2	---	1.45	---	---	3.96	1.22	---	0.537	0.557	7.72
4	---	0.311	---	---	1.60	---	---	4.05	---	5.96
6	0.223	.084	---	1.84	---	---	0.522	---	---	2.67
8	---	---	---	---	0.165	---	---	.263	---	0.428
10	---	---	---	---	1.48	---	---	2.06	.024	3.56
14	---	.541	0.326	---	---	1.16	---	---	---	2.03
18	---	---	---	---	---	---	---	---	---	---
20	---	---	.238	---	.071	---	---	---	---	.309
22	---	---	.129	---	---	.776	---	---	.632	1.54
26	---	---	1.46	---	.303	.538	---	---	---	2.30
28	---	---	---	---	---	1.73	---	---	.136	1.87
30	---	---	---	---	---	---	---	---	---	---
32	---	---	---	---	---	---	---	---	---	---
34	---	---	---	---	---	---	---	---	---	---
Subtotal	0.223	2.39	2.15	1.84	7.58	5.42	0.522	6.91	1.35	28.4
T. 140 N., R. 99 W.										
sec. 2	0.010	---	---	0.265	---	---	0.015	---	---	0.290
10	---	---	---	---	---	---	---	---	---	---
12	---	---	---	---	---	---	---	---	---	---
14	---	---	---	---	---	---	---	---	---	---
22	---	0.065	---	---	0.566	---	---	---	---	.631
24	---	---	---	---	---	---	---	---	---	---
26	---	---	---	---	.602	---	---	---	0.037	.639
34	---	---	---	---	---	---	---	---	2.54	2.54
Subtotal	0.010	0.065	---	0.265	1.17	---	.015	---	2.58	4.10
T. 141 N., R. 97 W.										
sec. 32	---	---	---	---	2.06	---	---	1.27	---	3.33
Subtotal	---	---	---	---	2.06	---	---	1.27	---	3.33
T. 141 N., R. 98 W.										
sec. 26	---	---	---	---	---	---	---	---	---	---
32	0.032	---	---	0.421	---	---	0.021	---	---	0.474
34	---	---	---	---	---	---	.018	---	---	.018
Subtotal	0.032	---	---	0.421	---	---	0.039	---	---	0.492
Total	0.265	2.45	2.15	2.53	10.8	5.42	0.576	8.18	3.93	36.3

Table 12.--Estimated identified coal resources of the Fryburg (VIII) lignite bed under >200 feet of overburden, Sentinel Butte Member, Fort Union Formation, Rattlesnake Butte EMRIA study site, Stark, Billings and Dunn Counties, North Dakota as of August 1, 1980

[Leaders (---) indicate not present. In millions of short tons. 1 foot = 0.305 meters; 1 short ton = 0.907 metric ton; numbers are rounded to three significant figures.]

Location	Measured			Indicated			Inferred			Total
	Thickness of coal in feet			Thickness of coal in feet			Thickness of coal in feet			
	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	
T. 140 N., R. 98 W.										
sec. 2	---	0.554	---	---	0.114	---	---	0.137	---	0.805
4	---	---	---	---	---	---	---	.082	---	.082
6	0.027	---	---	0.037	---	---	---	---	---	.064
8	---	---	---	---	---	---	---	---	---	---
10	---	---	---	---	---	---	---	.652	---	.652
14	---	---	---	---	---	---	---	---	---	---
18	---	---	---	---	---	---	---	---	---	---
20	---	---	---	---	---	---	---	---	---	---
22	---	---	---	---	---	---	---	---	---	---
26	---	---	---	---	---	---	---	---	---	---
28	---	---	---	---	---	---	---	---	---	---
30	---	---	---	---	---	---	---	---	---	---
32	---	---	---	---	---	---	---	---	---	---
34	---	---	---	---	---	---	---	---	---	---
Subtotal	0.027	0.554	---	0.037	0.114	---	---	0.871	---	1.60
T. 140 N., R. 99 W.										
sec. 2	---	---	---	---	---	---	---	---	---	---
10	---	---	---	---	---	---	---	---	---	---
12	---	---	---	---	---	---	---	---	---	---
14	---	---	---	---	---	---	---	---	---	---
22	---	---	---	---	---	---	---	---	---	---
24	---	---	---	---	---	---	---	---	---	---
26	---	---	---	---	0.024	---	---	---	---	0.024
34	---	---	---	---	---	---	---	---	---	---
Subtotal	---	---	---	---	0.024	---	---	---	---	0.024
T. 141 N., R. 97 W										
sec. 32	---	---	---	---	0.070	---	---	---	---	0.070
Subtotal	---	---	---	---	0.070	---	---	---	---	0.070
T. 141 N., R. 98 W.										
sec. 26	---	---	---	---	---	---	---	---	---	---
32	---	---	---	---	---	---	---	---	---	---
34	---	---	---	---	---	---	---	---	---	---
Subtotal	---	---	---	---	---	---	---	---	---	---
Total	0.027	0.554	---	0.037	0.208	---	---	0.871	---	1.70

Table 13.--Summary of estimated identified coal resources of the Fryburg (VIII) lignite bed, Sentinel Butte Member, Fort Union Formation, Rattlesnake Butte EMRIA study site, as of August 1, 1980

[Leaders (---) indicate not present. In millions of short tons. 1 foot = 0.305 meters. 1 short ton = 0.907 metric ton; numbers are rounded to three significant figures.]

	T. 140 N. R. 98 W.	T. 140 N. R. 99 W.	T. 141 N. R. 97 W.	T. 141 N. R. 98 W.	Total
<hr/>					
Coal bed 2 1/2 to 5 feet thick					
Measured resources	1.63	1.24	---	0.430	3.30
Indicated resources	5.69	3.50	---	2.54	11.7
Inferred resources	.718	.345	---	2.91	3.97
Total	8.04	5.09	---	5.88	19.0
<hr/>					
Coal bed 5-10 feet thick					
Measured resources	5.69	1.32	---	---	7.01
Indicated resources	23.4	9.39	2.41	---	35.2
Inferred resources	9.41	1.53	1.57	---	12.5
Total	38.5	12.2	3.98	---	54.7
<hr/>					
Coal bed >10 feet thick					
Measured resources	12.2	1.32	---	---	13.5
Indicated resources	40.3	6.54	---	---	46.8
Inferred resources	10.9	8.71	---	---	19.6
Total	63.4	16.6	---	---	79.9
<hr/>					
Total identified resources	110.	33.9	3.98	5.88	154.

Table 14.—Estimated identified coal resources of the HT Butte (XIII) lignite bed under >200 feet of overburden, Tongue River Member, Fort Union Formation, Rattlesnake Butte EMRIA study site, Stark, Billings and Dunn Counties, North Dakota as of August 1, 1980

[Leaders (---) indicate not present. In millions of short tons. 1 foot = 0.305 meters; 1 short ton = 0.907 metric ton; numbers are rounded to three significant figures.]

Location	Measured			Indicated			Inferred			Total
	Thickness of coal in feet			Thickness of coal in feet			Thickness of coal in feet			
	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	
T. 140 N., R. 98 W.										
sec. 2	---	---	---	---	---	---	4.17	---	---	4.17
4	---	0.207	---	---	2.18	---	---	5.34	---	7.72
6	---	.043	---	---	2.91	---	---	8.83	---	11.8
8	---	1.15	---	---	2.35	2.30	---	1.19	1.13	8.12
10	---	---	---	---	---	---	2.71	---	---	2.71
14	0.014	---	---	0.596	---	---	0.848	---	---	1.46
18	---	---	---	---	---	---	---	2.51	9.39	11.9
20	---	---	1.38	---	---	8.50	---	---	4.16	14.0
22	---	---	---	---	2.86	---	---	2.45	---	5.31
26	---	---	---	---	---	---	1.13	---	---	1.13
28	---	.590	0.788	---	5.09	0.036	---	1.38	---	7.88
30	---	.115	---	---	2.80	---	---	2.05	---	4.97
32	---	---	---	---	2.89	---	---	2.23	---	5.12
34	---	.326	---	---	1.14	---	---	3.71	---	5.18
Subtotal	0.014	2.43	2.17	0.596	22.2	10.8	8.86	29.7	14.7	91.5
T. 140 N., R. 99 W.										
sec. 2	---	---	---	---	---	---	---	8.31	---	8.31
10	---	0.554	---	---	3.44	---	---	4.23	---	8.22
12	---	---	---	---	---	---	---	7.73	---	7.73
14	---	.371	---	---	3.46	---	---	5.81	---	9.64
22	---	.561	---	---	3.41	---	---	2.26	---	6.23
24	---	.894	---	---	4.53	---	---	3.98	---	9.40
26	---	---	---	---	---	---	---	6.21	---	6.21
34	---	---	---	---	---	---	---	4.63	---	4.63
Subtotal	---	2.38	---	---	14.8	---	---	43.2	---	60.4
T. 141 N., R. 97 W.										
sec. 32	---	---	---	0.506	---	---	1.62	---	---	2.13
Subtotal	---	---	---	0.506	---	---	1.62	---	---	2.13
T. 141 N., R. 98 W.										
26	---	---	---	---	0.703	---	---	0.194	---	0.897
32	---	---	---	---	.621	---	---	7.30	---	7.92
34	---	---	---	---	0.813	---	---	3.10	---	3.91
Subtotal	---	---	---	---	2.14	---	---	10.6	---	12.7
Total	0.014	4.81	2.17	1.10	39.1	10.8	10.5	83.5	14.7	167.

Table 15.--Estimated identified coal resources of the HT Butte (XIII) rider lignite bed under >200 feet of overburden, Tongue River Member, Fort Union Formation, Rattlesnake Butte EMRIA study site, Stark, Billings and Dunn Counties, North Dakota as of August 1, 1980

[Leaders (---) indicate not present. In millions of short tons. 1 foot = 0.305 meters; 1 short ton = 0.907 metric ton; numbers are rounded to three significant figures.]

Location	Measured			Indicated			Inferred			Total
	Thickness of coal in feet			Thickness of coal in feet			Thickness of coal in feet			
	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	2 1/2-5	5-10	>10	
T. 140 N., R. 98 W.										
sec. 2	---	---	---	---	---	---	2.03	---	---	2.03
4	0.145	---	---	1.86	---	---	3.37	---	---	5.38
6	---	---	---	---	---	---	---	---	---	---
8	---	---	---	---	---	---	---	---	---	---
10	---	---	---	---	---	---	2.41	---	---	2.41
14	.015	---	---	1.36	---	---	1.20	---	---	2.58
18	---	---	---	---	---	---	---	---	---	---
20	---	---	---	---	---	---	---	---	---	---
22	---	---	---	1.78	---	---	0.687	---	---	2.47
26	---	---	---	---	---	---	5.27	---	---	5.27
28	.317	---	---	1.23	---	---	.155	---	---	1.70
30	---	---	---	---	---	---	---	---	---	---
32	---	---	---	---	---	---	---	---	---	---
34	---	---	---	---	---	---	---	---	---	---
Subtotal	0.477	---	---	6.23	---	---	15.1	---	---	21.8
T. 140 N., R. 99 W.										
sec. 2	---	---	---	---	---	---	---	---	---	---
10	---	---	---	---	---	---	---	---	---	---
12	---	---	---	---	---	---	---	---	---	---
14	---	---	---	---	---	---	---	---	---	---
22	---	---	---	---	---	---	---	---	---	---
24	---	---	---	---	---	---	---	---	---	---
26	---	---	---	---	---	---	---	---	---	---
34	---	---	---	---	---	---	---	---	---	---
Subtotal	---	---	---	---	---	---	---	---	---	---
T. 141 N., R. 97 W.										
sec. 32	---	---	---	---	---	---	---	---	---	---
Subtotal	---	---	---	---	---	---	---	---	---	---
T. 141 N., R. 98 W.										
sec. 26	---	---	---	0.502	---	---	0.060	---	---	0.562
32	---	---	---	---	---	---	---	---	---	---
34	---	---	---	.616	---	---	1.31	---	---	1.93
Subtotal	---	---	---	1.12	---	---	1.37	---	---	2.49
Total	0.477	---	---	7.35	---	---	16.5	---	---	24.3

Table 16.--Summary of estimated identified lignite resources of the HT Butte (XIII) and HT Butte rider lignite beds, Tongue River Member, Fort Union Formation, Rattlesnake Butte EMRIA study site, as of August 1, 1980

[Leaders (---) indicate not present. In millions of short tons. 1 foot = 0.305 meters. 1 short ton = 0.907 metric ton; numbers are rounded to three significant figures.]

	T. 140 N. R. 98 W.	T. 140 N. R. 99 W.	T. 141 N. R. 97 W.	T. 141 N. R. 98 W.	Total
<hr/>					
Coal bed 2 1/2 to 5 feet thick					
Measured resources	0.491	---	---	0.491	
Indicated resources	6.83	---	0.506	1.12	8.46
Inferred resources	24.0	---	1.62	1.37	27.0
Total	31.3	---	2.13	2.49	35.9
<hr/>					
Coal bed 5-10 feet thick					
Measured resources	2.43	2.38	---	---	4.81
Indicated resources	22.2	14.8	---	2.14	39.1
Inferred resources	29.7	43.2	---	10.6	83.5
Total	54.3	60.4	---	12.7	127.
<hr/>					
Coal bed >10 feet thick					
Measured resources	2.17	---	---	---	2.17
Indicated resources	10.8	---	---	---	10.8
Inferred resources	14.7	---	---	---	14.7
Total	27.7	---	---	---	27.7
<hr/>					
Total identified resources	113.	60.4	2.13	15.2	191.

Measured - Resources are computed from thicknesses revealed in outcrops, trenches, mine workings, and drill holes. The points of observation and measurement are so closely spaced and the thickness and extent of coals are so well defined that the tonnage is judged to be accurate within 20 percent of true tonnage. Although the spacing of the points of observation necessary to demonstrate continuity of the coal differs from region to region according to the character of the coal beds, the points of observation are no greater than 1/2 mile (0.8 km) apart. Measured coal is projected to extend as a 1/4 mile (0.4 km) wide belt from the outcrop or points of observation or measurement.

Indicated - Resources are computed partly from specific measurements and partly from projections of visible data for a reasonable distance on the basis of geologic evidence. The points of observation are 1/2 (0.8 km) to 1 1/2 miles (2.4 km) apart. Indicated coal is projected to extend as a 1/2 mile (0.8 km) wide belt that lies more than 1/4 mile (0.4 km) from the outcrop or points of observation or measurement.

Inferred - Quantitative estimates are based largely on broad knowledge of the geologic character of the bed or region, because few measurements of bed thickness are available. The estimates are based primarily on an assumed continuation from measured and indicated coal for which geologic evidence exists. The points of observation are 1 1/2 (2.4 km) to 6 miles (9.6 km) apart. Inferred coal is projected to extend as a 2 1/4-mile (3.6 km) wide belt that lies more than 3/4 mile (1.2 km) from the outcrop or points of observation or measurement.

CHARACTERISTICS USED IN RESOURCE EVALUATION

The coal characteristics that are commonly used in classifying coal resources are: rank, grade, and density of the coal; thickness of the coal beds; and thickness of the overburden. Rank and grade have been discussed previously.

Density

The density of the coal ranges considerably with differences in rank and ash content. In areas such as the Rattlesnake Butte EMRIA study site, where true density of the coal has not been determined, an average density based on many determinations in other areas is used to express the density of the coal for resource calculations. The average density of this lignite is assumed to be 1750 tons per acre-foot, and the specific gravity is 1.29.

Thickness of beds

Because of the important relationship of coal-bed thickness to utilization potential, most coal resource estimates prepared by the U.S. Geological Survey are tabulated according to three thickness categories. The thickness categories used for lignite are thin 2.5 to 5 feet (0.75 to 1.5 m); intermediate 5 to 10 feet (1.5 to 3 m); and thick more than 10 feet (3 m). About 32% of the estimated resources of the study area is in the thick category, about 56% is in the intermediate category and 12% is in the thin category. By way of comparison, Averitt (1975, fig. 5 and p. 37) showed the distribution of the estimated resources of 21 states as 42 percent in the thin category, 25 percent in the intermediate category, and 33 percent in the thick category.

Thickness of overburden

All of the estimated lignite resources in the Rattlesnake Butte EMRIA site are overlain by less than 300 feet (91 m) of overburden.

SUMMARY OF RESOURCES

Total estimated identified lignite resources in the Rattlesnake Butte EMRIA site are 484 million tons (439 million metric tons). Of this amount, 58.3 million tons (52.9 million metric tons) are in beds 2.5-5 feet thick, 269 million tons (244 million metric tons) are in beds 5-10 feet thick, and 156 million tons (141 million metric tons) are in beds more than 10 feet thick. Measured resources total 55.7 million tons (50.5 million metric tons), indicated resources total 233 million tons (211 million metric tons) and inferred resources total 196 million tons (178 million metric tons).

The estimated resources presented in this report are original resources; that is, resources in the ground before the beginning of mining operations.

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