Coal Deposits of the United States of America

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Abstract. America is often referred to as the “Saudi Arabia of coal”. The United States of America has the biggest supply of coal reserves in the world. Over 27 % of total coal reserves exist in the United States, that means 249 billion tons are recoverable reserves. The supplies are enough for 250 years at current use levels.

The knowledge of the size, distribution and quality of the nations coal resource is very important for governmental planning, industrial planning and growth, the solution of current and future problems related to air, water and land degradation, and for meeting the short- to long- term energy needs of the country.

Introduction

Coal is the most abundant fossil fuel in the United States. The origin goes back 300 million years ago. Coal is a combustible, black or brownish sedimentary rock which is composed mainly of carbon, hydrogen and oxygen. Coal was formed as organic plant matter decayed, compressed and altered by geological processes over millions of years. Because of differences in the development of coal concerning pressure, temperature and time there are different types of coal. These types are described after their rank. There are four basic types which can be distinguished: lignite, subbituminous, bituminous and anthracite.

Lignite are brownish black coals in the lowest rank. It has a high moisture and ash content and a low heating value. It is friable and soft. This coal is typically used in electricity generation.

Subbituminous is also a soft coal but has a lower moisture and ash content and higher heat content than lignite. This rank of coal is used in electricity generation.

Bituminous is a high rank coal with high heat and low moisture and ash contents and is harder than lower ranked coals. It is typically used in electricity generation and steel-making processes.

Anthracite is the highest rank coal with a high heat conent and little moisture. It is hard and shiny or lustrous. It is used in residential and commercial heating as well as mix of industrial applications. Some waste products of anthracite piles are used in energy generation.

In this order the moisture and ash content decrease and the heating value increase.

In the United States all of these types occur (**Fig.1**).

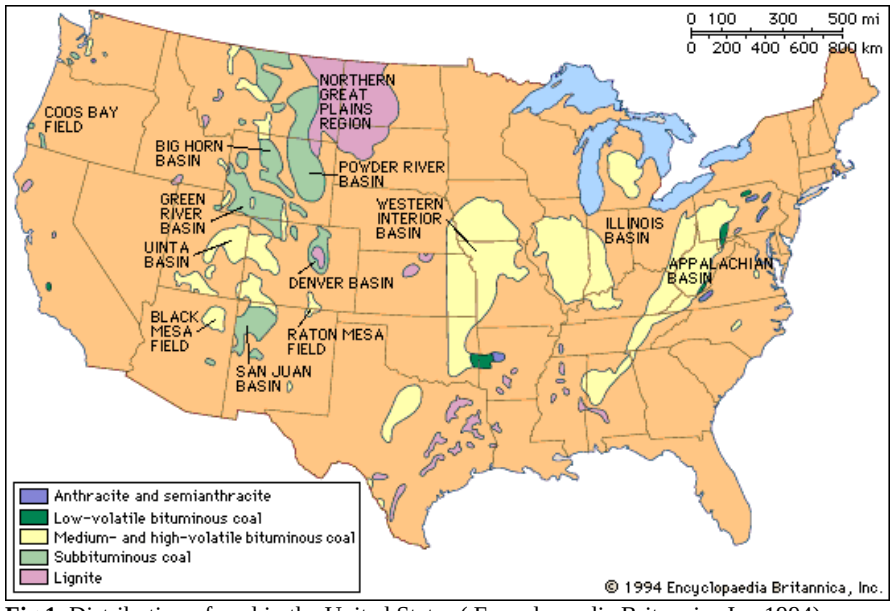

Fig.1. Distribution of coal in the United States (Encyclopaedia Britannica,Inc 1994).

Regarding the coal ranks, bituminous is mined mostly in the East and the Midwest, subbituminous is mined only in the western states, lignite in the Gulf Coast and North Dakota and anthracite in small quantities in Pennsylvania.

Coal regions of the United States of America

The Unites States are devided into six great areas (**Fig.2**).

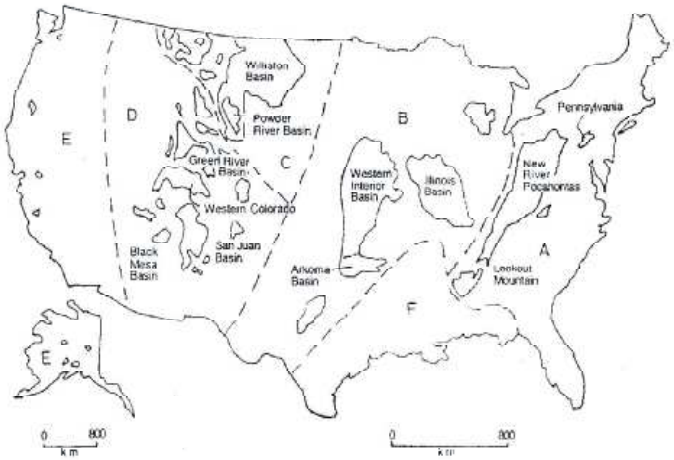

Fig.2. Coal deposits of the USA: A. Appalachian Province; B. Interior Province; C. Northern Great Plains; D. Rocky Mountains Province; E. Pacific Coast Province; F. Gulf Coastal Plain Province (reproduced by permission of Dargo Associates Ltd).

Appalachian Province

The Appalachian Province is also called the Eastern Province in which 40 % of the nation`s coal is produced in the six states lying in the northern and central Appalachian Province (includes Ohio, Pennsylvania, West Virginia, Maryland, Virginia, Kentucky).

In this Province there is the oldest and most extensivley developed coal province in the United States. The coal is of Carboniferous age and the rank increases from west to east, from high volatile bituminous coal to low volatile bituminous coal and anthracite. The sulphur content is high in the west and decreases to the east.

The Appalachian Province contains two-fifths of bituminous coal and nearly all the anthracites and over 60 coal beds and zones are mined. 65 % of coal is totally produced from just 10 coal beds or zones. The primary use of this coal is for energy commodity.

Interior Province

The Interior Province contains separate basins with carboniferous bituminous coals. The rank increases from high volatile bituminous coal in the central and northern areas to high volatile bituminous coals in the west. The sulphur content lies between 3 and 7 % and so the demand decreases because electric utilities changed from high sulphur to low sulphur coals from the west (e.g Powder River Basin).

Coal-seams range from 0,5 m to 2,5 m in thickness and cover thousands of square kilometers.

The coal of the Western Interior Basin is characterised by thinner but laterally extensive seams. In the Arkoma Basin there are semi-anthracites with low sulphur content which have good coking properties.

The Northern Great Plains Province

The Northern Great Plains Province includes coals of Cretaceous to Tertiary age. The Powder River Basin is the main coal-production area and lies in northern Wyoming and southeastern Montana. The main reserves are subbituminous coal and lignite which get a higher significance in recent years because of their low sulphur content.

In northern Montana there is Cretaceous coal and bituminous in rank.

The Powder River Basin

Chief coal resources of subbituminous rank exist in the Fort Union Formation in the Powder River Basin in Wyoming and Montana. Fort Union strata constitute the surface bedrock along the borders of the Powder River Basin. This Formation comprises predominantly nonmarine series of interbedded sandstone, shale, siltstone, clay, freshwater limstone and thick coal beds.

The Fort Union Formation is of Paleocene age and devided in three subgoups. The oldest group is the Tullock Member, followed by the Lebo Shale Member and finally the Tongue River Member with the most coal zones.

Beneath the Fort Union Formation the Cretaceous Lance Formation crops out. And in the hanging wall is the Eocene Wasatch Formation located.

The stratification is shown in **Fig.3**.

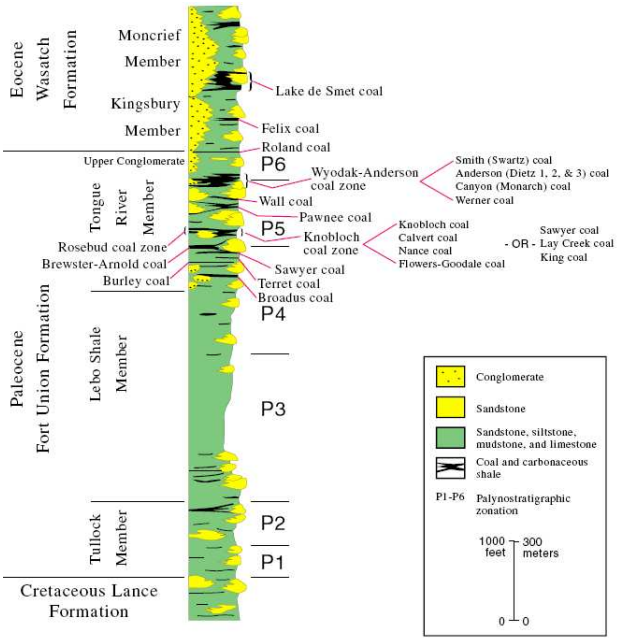

Fig.3. Stratification of the Fort Union Formation (USGS Professional Paper 1625-A).

The Fort Union Formation covers 22 000 km² and has been contributed more than 308 millions tons in 1998. This concludes 34 per cent of the United States` coal production. The coal is produced from 25 coal strip mines in the Wyodak-Anderson and Rosbud coal zones and delivers energy fuel to 144 power plants.

In the next several decades the Fort Union coal deposits in the basin will be the focus because of their clean and favourable characteristics like low sulphur and ash content.

Important mines in the Powder River Basin is for instant the Wyodak mine which is the oldest operating mine of the nation`s surface mines with an annual production of 3 million tons. The Cordero Rojo Complex produced 24 million tons per year with an ash content of 5,7 % and sulphur content of 0,37 %. Recoverable reserves are 350 million tons. Annually 15 million tons are produced by the Coal Creek with an ash content of 5,5 % and sulphur content of 0,33 %. Reserves are 290 million tons. Also important is the North Antelope/ Rochelle Complex with a coal production of 70 million tons per year and total reserves of 1.375 million tons per year. The ash content accounts for 4,5 – 4,7 % an the sulphur content accounts for 0,21-0,24 %.

The Map (**Fig.4**) shows important mines and their location.

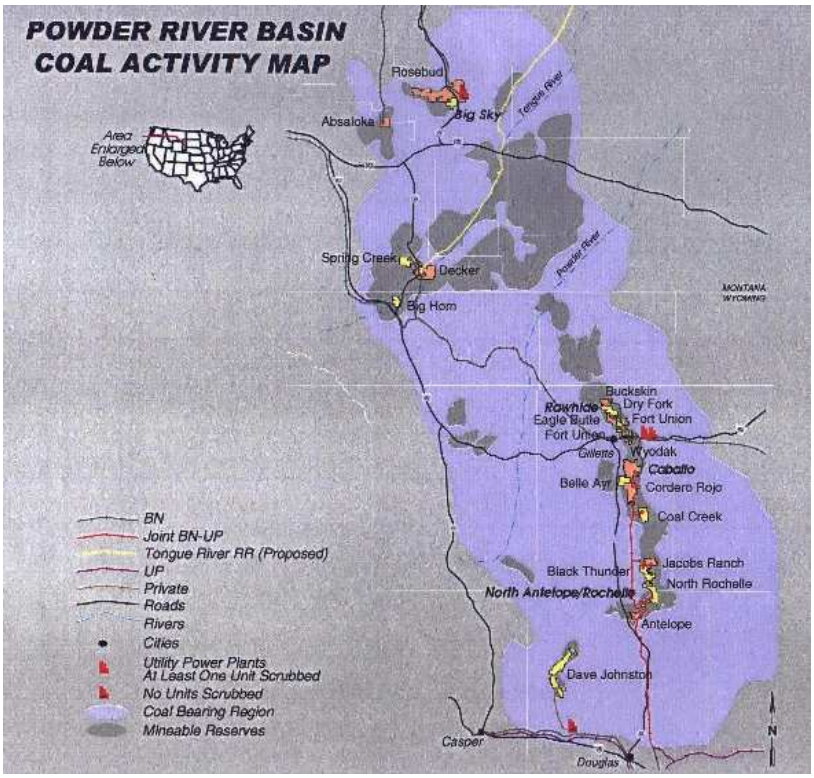

Fig.4. Location of important mines (Caballo Puplication 2000).

Caballo Mine

The Caballo Mine is located in Campbell County, about 32 kilometers southeast of Gilette in Wyoming. The owner of this mine is the Peabody Group (Powder River Coal Company). The first mining of coal started in 1978 and now over 400 employers are salaried. The Caballo Mine is one of the nation`s safest U.S. mines.
The coal of the Caballo Mine is mined from the Wyodak-Anderson seam with a thickness of 21 meters. The overburden is about 61 meter thick. 33 million tons of coal was stripped in the year 2006 and 931 millions tons of reserves exists that are recoverable by surface mining methods.
The Caballo Mine coal is favoured today because of their low sulphur and ash contents. Facts are shown in **Table 1**.

Table.1. Caballo Mine coal content information (Caballo Puplication 2000).

Quality	
BTU/lb	19,8 MJ/kg
Sulfur content (dry)	0,36% … 4732 kcal/kg
Ash content (dry)	5,00%
Moisture content (ash free)	29,90%

Rocky Mountains Province

The Rocky Mountains Province contains coal obtained in intermontane basins.

In the Green River Basin the coal-bearing sediments are of upper Cretaceous to lower Tertiary age and the thickness accounts for more than 900 m, containing multiple bedded coal seams. Late Cretaceous to lower Tertiary coal is also found in the Piceance Basins in which sediments are over 3000 m thick. The San Juan Basin contains late Cretaceous coal.
Cretaceous coal is mostly bituminous and subbituminous and the Tertiary coals are subbituminous and lignite. The seams are 3 m to 10 m thick.
The coal has low sulphur content under 1 %. There are small areas of coal suitable for coking purposes.

The Pacific Coast Province

In the Pacific Coast Province coal is found in small wide dispersed basins from California to Washington. The coal is of Tertiary age and has been tectonised and metamorphosed.

The area of Alaska is not completely explored but many deposits of subbituminous and high volatile bituminous coal have been identified.
Coal reserves in Alsaka are estimated to 1.850 billion tons, but only 10 % are recoverable. There is one operating coal mine in Alaska the Usibelli Coal Mines at Healy produce about 700.000 tons of coal annually. This coal supplies only 6 % of the energy.

A significant factor in the slow development of Alaska's huge coal resources is the quality of the coal itself. Most good bituminous and anthracite coals have their origins in terrestrial plants that grew 300 million years ago, during the Carboniferous period. Burial under overlying sediments brought high temperatures and pressures acting over a long period of time to develop high-quality coals. But most of Alaska's coals are much

younger. They were developed in the Cretaceous and Tertiary periods. Many of these younger Alaskan coals have not cooked long enough at sufficiently high temperature (100° to 400°C) to coalify into the high-quality bituminous and anthracite coals most desired. The majority of the Alaskan coal is lignite, sub-bituminous and bituminous.

Gulf Coastal Plain Province

This Province contains lignites of Tertiary age and the seam ranges from 1 m to 7,5 m in thickness. The use is primarily for electricity generation.

Coal production in the United States

Since 100 of years coal has been an energy source in the United States. It helped to provide many basic needs like transportation for people and heating. Coal production grew permanently from the colonial period and has a long tradition.

The removal of production from eastern coalfields to the western States is the most important development in the last 30 years (**Table 2**). The coal production in the Western Region like the Rocky Mountains Province or the Nothern Great Plains steadly grew while the Appalachian and Interior Region stay the same.

Table 2. Production and Productivity at U.S. coal mines (Energy Information Administration).

Item	1973	1983	1993	2003
Production (thousand short tons)				
United States	598,568	782,091[1]	945,424	1,071,753
underground	300,080	300,379[1]	351,053	352,785
surface	298,491	481,713[1]	594,371	718,968
Appalachian Region	381,629	377,952	409,718	376,775
underground	239,636	230,191	257,433	244,468
surface	141,993	147,761	152,285	132,307
Interior Region	156,412	173,407	167,174	146,276
underground	56,060	49,437	56,065	52,173
surface	100,352	123,970	111,109	94,103
Western Region	60,530	225,276	368,532	548,701
underground	10,036	18,691	37,555	56,144
surface	50,494	206,584	330,977	492,557

The coal production in 1950 was 508 million tons. The coal extraction costs have been kept relativley low owing to high mine productivity. In

2003 the production was 97 billion tons. This was an average annual increase in coal production of 1,2 % per year.

Figure 5 (**Fig.5**) shows the trend of coal production.

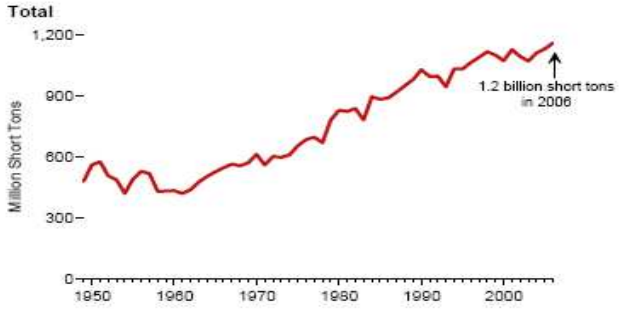

Fig.5. Trend in coal production from 1949 to 2006 (after Energy Information Administration - Annual Energy Review 2006).

In recent years about 90 % of coal production in the United States has been consumed at domestic electric power plants. Because of secure, abundant domestic reserves and relativley low prices coal use grew. Mine productivity has increased because of the demand and so larger and larger mines accrued. Also larger, efficient mining machinery are used, technology and control systems advanced.

Today the United States are the second largest global consumer of coal after China.

References

Thomas, L. (2005) Coal Geology, John Wiley & Sons, Ltd, pp 54- 55

USGS (2001), Professional Paper 1625-C

USGS (1999), Professional Paper 1625-A

USGS (1998), U.S. Geological Survey Open- File Report 97-134

USGS (2002) Coal – A Complex Natural Resource,
U.S. Geological Survey Circular 1143

http://energy.usgs.gov/coal.html

http://www. Americancoalcouncil.org

http://www.peabodyenergy.com/

https://www.cia.gov/library/publications/the-world-factbook/

http://www.acaa-usa.org/

http://www.eia.doe.gov/

http://www.worldcoal.org/