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RESOURCES, QUALITY AND ECONOMIC IMPORTANCE OF SOLID FOSSIL FUELS IN TURKEY

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(3 figures and 6 tables)

ABSTRACT. Turkey possesses fossil fuel resources of hard coal, lignite, bituminous shale, asphaltite, peat, petrol and natural gas. Among these, the hard coal and lignite have the greatest importance in energy production and for the national economy. The hard coal reserve of Turkey is estimated to be 1.1 billion tonnes with a calorific value between 5650-7250 kcal/kg (23655-30354 kJ/kg). Lignites occur in the Eocene, Oligocene, Miocene and Pliocene basins all around Turkey. The majority of Turkish lignite deposits are worked in open-pit mines with the total lignite coal reserve estimated to be around 8.3 billion tonnes (by 2001 estimates). Lignites are mined by TKI (Turkish Coal Enterprises) at a rate between 60-65 million tonnes per year. Because of their low calorific values, most of the lignites produced are used in the electrical power plants. Whilst the total capacity of hard coal based power plants is 300 MW, that of the lignite based ones is 5913 MW. The total reserve of the asphaltite deposits is estimated to be 82 million tonnes. Bituminous shales amount to a total reserve of approximately 1,641 million tonnes, but are not being utilized economically at present. Peat deposits are estimated to be in the order of 190 million tonnes, and are generally used only as plant soil. Among the above-mentioned solid fossil fuels, lignite has the greatest importance and potential. Based on the reserve estimation data available at present, it is safe to say that Turkey has enough solid fossil fuel reserves to meet most of its energy needs for many years to come.

Keywords: Turkey, lignite, hard coal, bituminous coal, asphaltite, peat.

1. Introduction

In this paper general information is given about the reserve, quality and economic importance of solid fossil fuels in Turkey. Solid fossil fuels have been explored and evaluated by the General Directorate of Mineral and Exploration (MTA), and exploited using various mining methods by the Turkish Coal Enterprises (TKI) and Turkish Hard Coal Enterprises (TTK). According to recent studies (MTA 1993, 2002) there are 181 well explored lignite deposits and 98 lignite deposits which require further investigation. There is very little information about many of the privately owned small lignite deposits.

Generally, large lignite deposits are mined by TKI and low reserve lignite deposits are mined by private enterprises. Under the management of TKI there are 15 subsidiary establishments producing coal and marketing it. Subsidiary establishments are scattered over the country. These are located as shown in Fig. 1: Dodurga-Çorum (ADL, Alpagut Dodurga Lignite Establishment), Aşkale-Erzurum (DLI, Eastern Lignite Establishment), Oltu-Erzurum (OLI, Oltu Lignite Establishment), Çizre-Şırnak (GAL, Southeast Anatolia Lignite Establishment), Çan-Çanakkale (ÇLI, Çan Lignite Establishment), Saray-Tekirdağ (TLI, Tekirdağ Lignite Establishment), Keles-Bursa (KLI, Keles Lignite Establishment), Orhaneli-Bursa (BLI, Bursa Lignite Establishment), Ilgın-Konya (ILI, Ilgın Lignite Establishment), Seyitömer-Kütahya (SLI, Seyitömer Lignite Establishment), Tavşanlı-Kütahya (GLI, Western Lignite Establishment), Soma-Manisa (ELI, Aegean Lignite Establishment), Göynük-Bolu (GÖLI, Göynük Lignite Establishment), Yatağan-Muğla (GELI, South Aegean Lignite Establishment) and Milas-Muğla (YLI, Yeniköy Lignite Establishment).

Hard coals are produced only by TTK in Zonguldak from Armutçuk, Kozlu, Üzülmez Karadon and Amasra underground mines.

Asphaltite deposits are mined by TKI for domestic heating in southeast Turkey whilst peat deposits are mined by the private sector as plant soil in Turkey and bituminous shales are not yet mined in Turkey.

2. Hard Coal resources of Turkey

The most important hard coal reserves of Turkey are located only around Zonguldak province in the northwest of Anatolia (Fig. 1). 1.1 billion tonnes hard coal reserves has been proved according to the results of the studies in the Zonguldak basin (Tab. 1). Average net calorific value is 6000 kcal/kg (25120 kJ/kg; Tab. 2). This basin

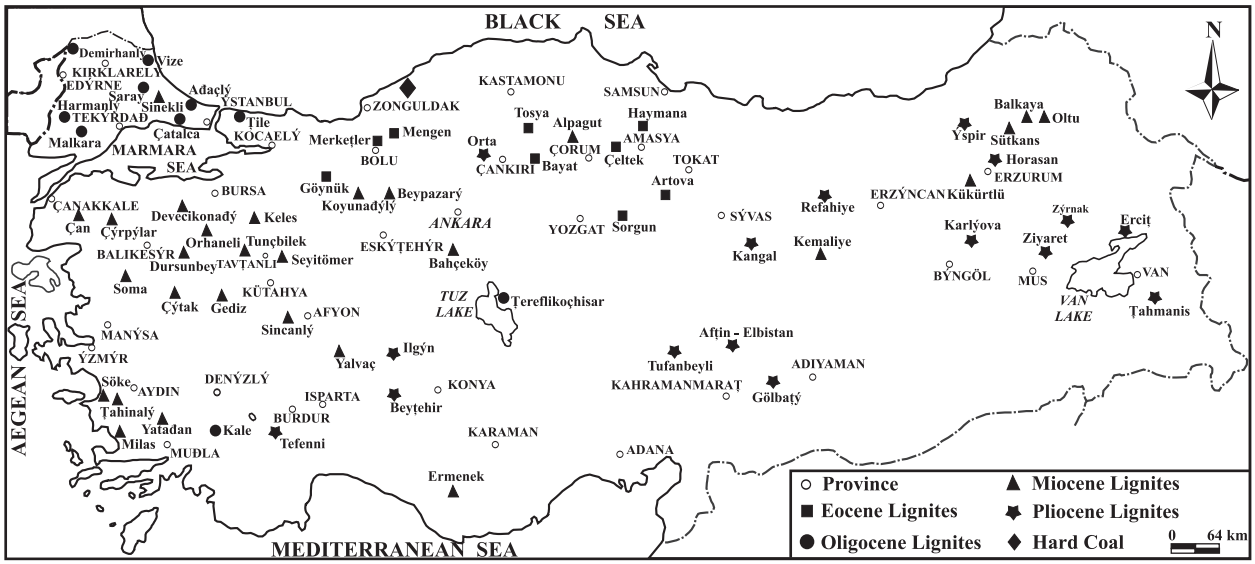

Figure 1. Hard coal and lignite deposits of Turkey.

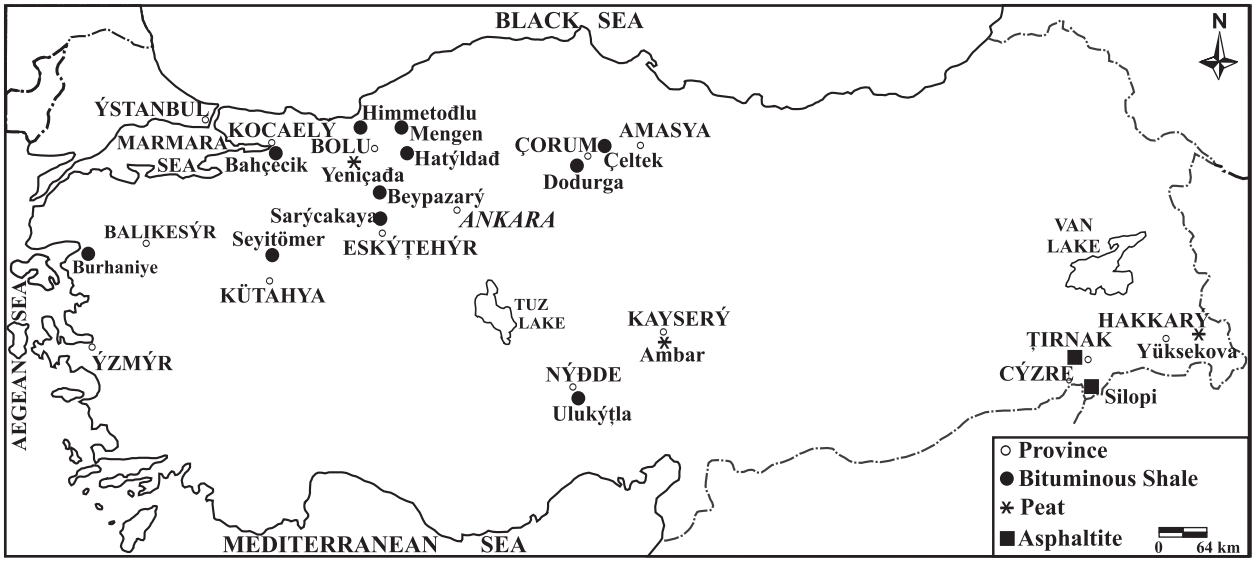

Figure 2. Asphaltite, bituminous shales and peat deposits of Turkey.

covers the region from Karadeniz Ereğli to Kandilli, Zonguldak, Amasra, Pelitovası, Azdavay and Söğütözü (SPD 2001). Carboniferous hard coals have very complex structures because of the influence of Hercynian and Alpine orogenesis. Although a great number of coal seams are located in the basin, only 22 coal seams can be mined economically. The dip of the seams varies between 0-90°. Hard coal is mined completely by underground mining methods at two different levels. One of them is +284m above the sea level and the second one is -560m below the sea level (SPD 2001).

There are some uneconomic hard coal fields in Antalya-Pamucak, Akseki-Güzelsu-Çukurköy and Diyarbakır-Hazro in the south of Turkey but these are important scientifically (SPD 2001). The Zonguldak hard coal basin is a paralic coal deposit (Nakoman, 1998). The substratum is made up of Devonian rocks whilst the hard coal-bearing units are composed of the Namurian Alacaağzı Formation, the Westphalian A Kozlu Formation and the Westphalian B to D-aged Karadon Formation. Cretaceous cover formations lie unconformably on the Upper Carboniferous coal bearing formations (Kerey et al., 1986).

Zonguldak hard coals are mainly consumed by the Çatalağzı thermal power plant and heavy industry plants. Some hard coals are suitable for use as coking coals.

ESTABLISHMENT	TOTAL RESERVE
ARMUTÇUK	39.957
KOZLU	170.829
ÜZÜLMEZ	323.853
KARADON	424.155
AMASRA	165083
TOTAL	1.123.877

(SPD, 2001)

Table 1. Hard Coal reserves in Turkey (1000 tonnes).

AS RECEIVED BASIS				
MOISTURE	ASH	VOLATILE MATTER	FIXED CARBON	CALORIFIC VALUE
(%)	(%)	(%)	(%)	(kcal/kg)
18	11	26	55	6000

(SPD, 2001)

Table 2. Chemical properties of Hard Coals in Turkey.

3. Lignite

Lignite deposits (Fig. 1) are developed in compressed sedimentary basins within the mountain ranges formed by the Alpine orogeny in Turkey. Miocene and Pliocene aged lignite deposits have high reserve capacity compared to Eocene and Oligocene aged lignite deposits. Only the Oligocene lignites were formed in a paralic environment. Other deposits were formed in a limnic environment. The distribution of lignite deposits in Turkey is such that generally the Eocene lignites are found in northern Turkey, Oligocene lignites in northwestern Turkey, Miocene lignites in western Turkey, and Pliocene-Pleistocene lignites in eastern Turkey (Inaner & Nakoman, 1997).

Eocene lignites are located only in very restricted areas in Turkey because marine conditions prevailed until the end of the Oligocene over much of the country. Eocene lignites occur in northern Turkey parallel to the boundaries facing Anatolia within the Pontide system which was unaffected by tectonic movements at the locations suitable for coal deposition. These are the deposits of Bolu-Mengen, Bolu-Merkeşler, Bolu-Göynük, Yozgat-Sorgun, Amasya-Çeltek and Kastomonu-Tosya. Lignites are bright, brittle and have good quality. Reserves are small (Inaner & Nakoman, 1997).

Oligocene paralic lignites are generally found in northwest Turkey. Among these deposits are Tekirdağ-Saray, Tekirdağ-Malkara, Edirne-Demirhanlı and Kırklareli-Vize (Fig. 1). There are some other small lignite deposits in southwest Turkey and Ankara-Şereflikoçhisar in central Turkey. Coal seams are numerous but thin in these deposits. Reserves are higher than for the Eocene lignites, but their quality is poorer.

Miocene lignites are generally located in fault-bound basins in western Turkey (Fig. 1). Some of the most important Miocene lignites are Muğla-Yatağan, Muğla-Milas, Manisa-Soma, Ankara-Beypazarı, Kütahya-Seyitömer, Kütahya-Tunçbilek, Eskişehir-Koyunağılı, İstanbul-Sinekli, Bursa-Orhaneli, Bursa-Keles, Bursa-Devecikonağı, Çanakkale-Çan, Çanakkale-Çırpılar, Balıkesir-Dursunbey, Ankara-Bahçeköy, Erzincan-Kemaliye, Erzurum-Aşkale and Erzurum-Oltu (Inaner & Nakoman, 1997). Miocene lignites have very high reserve capacities. Despite their variability, Miocene lignites are generally good in quality. Lignite seams are few, usually one or two and rarely three, and their mineable thickness varies between 1-25 metres (Inaner & Nakoman, 1997). The majority of these deposits are worked in open pit mines, although there are also underground mines in the region. The lignite reserves of western Turkey contribute 33% to the total Turkish reserves (Inaner & Nakoman, 1993).

Pliocene lignites are generally located in eastern Turkey (Fig. 1). The Pliocene lignite deposits are: Kahramanmaraş-Afşin-Elbistan, Konya-Beyşehir, Konya-Ilgın, Burdur-Tefenni, Sivas-Kangal, Çankırı-Orta, Adıyaman-Gölbaşı, Bingöl-Karlıova, Adana-Tufanbeyli, Erzurum-Zırnak, Muş-Ziyaret, Van-Erciş, Erzurum-İspir, Erzurum-Horasan and Erzincan-Refahiye. These are limnic deposits with usually one or two coal seams. Mineable seams are thick but there are sterile partings within the seams. Most of these lignites have high moisture and ash contents and low calorific values. The average calorific values are about 1000 kcal/kg (4168 kJ/kg). However, these lignites usually have large reserves and are generally consumed in power plants. Deposits such as İspir, Erciş and Refahiye, which have small reserves, are used for regional domestic heating.

The majority of Turkish lignite deposits are worked as open-pit mines. Total lignite coal reserve is estimated to be around 8.257 billion tonnes according to 2001 estimates. Turkish lignite reserves represent around 2% of the world total (Köktürk, 1994). Investigations of privatizing lignite mining and the energy sector are going on in Turkey. Regional reserve distributions and average chemical properties of Turkish lignites are given in Table 3. The lignites have calorific values between 868-5000 kcal/kg (3634-20934 kJ/kg), water content between 10-55 %, ash content between 11-46 %, and total sulphur content between 0.2-4.5 %. Almost 80% of the total reserves have calorific values below 2500 kcal/kg (10467 kJ/kg), 13% are in the range 2500-3000 kcal/kg, while only 7% are over 3000 kcal/kg (12560 kJ/kg). The lignites having low calorific values are generally consumed in power plants whilst the lignites having relatively high calorific values are exploited for domestic and industrial use.

REGIONS	AGE	RESERVE	MOISTURE	S	ASH	CALORIFIC VALUE
		(10^9 tonnes)	(%)	(%)	(%)	(kcal/kg)
NORTH - WEST ANATOLIA REGION (Kütahya-Balıkesir-Bursa-Manisa-Çanakkale)	Miocene	2	20	1,7	20	3500
SOUTH - MIDDLE - ANATOLIA REGION (Adana-Kahramanmaraş)	Pliocene	4	50	2,0	20	1200
CENTER ANATOLIA REGION (Ankara-Çorum) (Konya-Çankırı-Sivas)(Yozgat)	Miocene Pliocene Eocene	1,45	30	3,2	25	3000
SOUTH WEST ANATOLIA REGION (Aydın-Muğla-Denizli-Isparta-Afyon) (Burdur)	Miocene Pliocene	0,9	30	2,0	20	2500
THRACE REGION (Tekirdağ-Edirne-Kırklareli-İstanbul)	Oligocene	0,4	30	3,0	20	2500
EAST ANATOLIA REGION (Bingöl-Erzincan-Van) (Erzurum)	Pliocene Miocene	0,2	20	1,2	20	3000
TOTAL		8,25	36,5	2,1	21	2240

(SPD, 2001)

Table 3. Regional reserve distributions and average chemical properties of Turkish lignites.

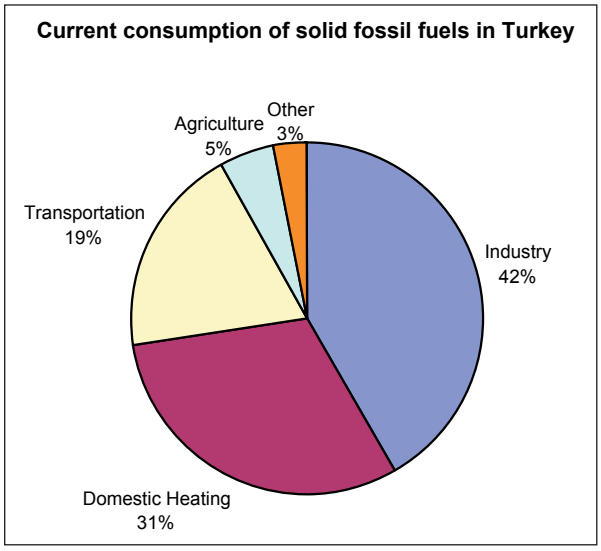

Figure 3. Current consumption of solid fossil fuels in Turkey.

Lignites are mined by TKI (Turkish Coal Enterprises) at a rate between 60-65 million tonnes per year. Whilst the total capacity of hard coal based power plants is 300 MW, that of the lignite based ones is 5913 MW. Current consumption of solid fossil fuels in Turkey is given in Figure 3 (SPD, 2001). According to this figure, 83% of the consumption of solid fossil fuels is from internal production and 17% is imported coal.

4. Bituminous shales

Bituminous shales (Fig. 2) are located in the west of Turkey (SPD, 2001), in Ankara-Beypazarı, Kütahya-Seyitömer, Niğde-Ulukışla, Bolu-Mengen, Kocaeli-Bahçecik, Bolu-Himmetoğlu, Bolu-Hatıldağ, Eskişehir-Sarıcakaya, Çorum-Dodurga, Amasya-Çeltek and Balıkesir-Burhaniye deposits. The total reserve is 1,641,381,000 tonnes as shown in Table 4. Average calorific value is about 1000

DEPOSIT	TOTAL RESERVE
Ankara - Beypazarı	327.684
Balıkesir - Burhaniye	81.568
Bolu - Himmetoğlu	78.372
Bolu - Mengen	133.320
Bolu - Hatıldağ	281.587
Kocaeli - Bahçeçik	42.000
Kütahya - Seyitömer	38.850
Niğde - Ulukışla	130.000
Eskişehir - Sarıcakaya	300.000
Çorum - Dodurga	138.000
Amasya - Çeltek	90.000
TOTAL	1.641.381

(SPD, 2001)

Table 4. Bituminous shale reserves in Turkey (1000 tonnes).

kcal/kg (41868 kJ/kg). The highest calorific value is 1390 kcal/kg (5820 kJ/kg) in the Göynük-Himmetoğlu field. The lowest calorific value is 541 kcal/kg (2265 kJ/kg). A small part of this reserve is suitable for open-pit mining, but underground mining is not feasible in today's economic climate. Bituminous shales are not utilized economically at present in Turkey.

5. Asphaltite

Asphaltite deposits (Fig. 2) are located only in Şırnak province and Silopi county in southeast Turkey (SPD, 2001). These deposits are of a vein type, their seams are thick and they are of is Upper Cretaceous- Paleocene age. The total reserve of the asphaltite deposits is estimated to be 79,969,000 tonnes as shown in Table 5. Their average net calorific values vary between 2876 and 5336 kcal/kg (12041-22341 kJ/kg) and generally the average value is approximately 5300 kcal/kg (22190 kJ/kg) in Şırnak and Silopi (Tab. 6). Ashes of the asphaltite contain the elements V2O5, NiO, MoO3 and U3O8 and thus it can not be economically utilized for local consumption in stoves used for domestic heating. These asphaltites are being considered for use as thermal power plant fuel in the coming years.

VEIN NAME	TOTAL RESERVE
Silopi - Harbul	25.765
Silopi - Silip	4.406
Silopi - Üçkardeşler	20.333
Şırnak - Avgamasya	7.642
Şırnak - Milli	6.481
Şırnak - A.Karatepe	5.000
Şırnak - Seridahlı	6.067
Şırnak - Nivekara	2.000
Şırnak - A.İspindoruk	1.100
Şırnak - Segürük	571
Şırnak - Rutkekurat	604
TOTAL	79.969

(SPD, 2001)

Table 5. Asphaltite reserves as vein in Turkey.

	AS RECEIVED BASIS				
DEPOSIT	MOIS-TURE	ASH	S	VOLATILE MATTER	CALORIFIC VALUE
	(%)	(%)	(%)	(%)	(kcal/kg)
Şırnak	6	31	4,5	39	5330
Silopi	6	31	4,0	30	5310

(SPD, 2001)

Table 6. Chemical properties of asphaltites in Turkey.

6. Peat

Peat deposits are located in various regions of Turkey (Fig. 2). Kayseri-Ambar, Hakkari-Yüksekova and Bolu-Yeniçağa are the most important of them (SPD, 2001). Peat deposits are estimated to be in the order of 190.000.000 tonnes, and are generally used as plant soil. They are not used for electricity generation because of their insufficient reserves and for environmental considerations.

7. Conclusions

Reserves of 8.3 billion tonnes of lignite, 1.1 billion tonnes of hard coal, 1.6 billion tonnes of bituminous shale, 0.190 billion tonnes of peat, 0.082 billion tonnes of asphaltite have been determined for the whole of Turkey by 2001 estimates (SPD, 2001).

Miocene and Pliocene lignites are the most important economic deposits in Turkey. Although Miocene lignites are generally of good quality, the Pliocene lignites have inferior calorific values. Oligocene lignite deposits contain smaller reserves than the Miocene and Pliocene lignite deposits. Eocene lignite deposits have higher calorific values and are of good quality but there are fewer reserves than other lignite deposits. Turkey's lignite production is about 60-65 million tonnes per year.

Only one mineable hard coal deposit is located in northwest Anatolia in Turkey and is of Westphalian age. Annual hard coal production from Zonguldak deposit is 2.5 million tonnes whilst other hard coal deposits in southern Turkey are not economic.

Asphaltite deposits located in southeast Anatolia are mined on a small scale.

Bituminous shales deposits are uneconomic and are not being mined in Turkey; whilst peat is utilized as plant soil and worked on a small scale. The authors are of the opinion that Turkey has enough solid fossil fuel reserves to meet most of the country's energy needs for many years to come.

8. Acknowledgements

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