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ECONOMIC EVALUATION OF BURSA–ORHANELI LIGNITE COALFIELD

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A b s t r a c t . Bursa–Orhaneli lignite coalfield is located in the North-West of Turkey. This coalfield has three sectors: Burmu, Çivili, and Sağırlar, having similar stratigraphic sequences in the northwest of Bursa Province. The mined coal seam is Miocene of age, and its thickness varies between 1.10–14.50 m. The pre-Neogene rocks in the area are made up of Palaeozoic aged metamorphic schists and marbles, and Upper Cretaceous aged ophiolites. The Neogene formations of detrital rocks with basal conglomerates, coal bearing marl and tuffites are found at the base, and volcanic basalt tuffs and andesite lava flows, at the top. The post-Neogene sediments are Pleistocene aged gravels and Holocene alluvium.

The deposit has been worked as an open-pit mine in the Burmu and Sağırlar sectors and is going to be worked by underground mining methods in the near future. The chemical analysis have shown that the percentage of water is 22.66–27.30%, ash 24.57–44.39%, volatile matter 18.52–29.44%, fixed carbon 23.87–29.52%, and total sulphur 1.84–2.64% in the original coal, and its calorific value is 2010–3032 kcal/kg, whereas the air dried coal is composed of 5.51–10.41% water, 26.99–54.18% ash, 21.83–35.49% volatile matter, 28.10–36.03% fixed carbon, and 2.42–3.06% total sulphur, with calorific value of 2483–3938 kcal/kg. The proven and workable lignite reserves are 60,877,079 and 47,308,406 tonnes respectively. Stripping and production operations are made by a dragline, excavators and trucks. Mined coal is used both in domestic heating and the Orhaneli thermic power plant, which has a capacity of 1x210 MW.

K e y w o r d s : lignite, reserves, coal quality, Bursa–Orhaneli coalfield, Turkey.

INTRODUCTION

The total lignite reserves of Turkey have reached 8.4 billion tonnes. Orhaneli lignite coal field has an important place in this reserve. Important Miocene aged lignite deposits appear in the western Anatolia, and Orhaneli lignite deposit is one of them.

Orhaneli lignite coal field was investigated by Mineral Research and Exploration General Directorate (M.T.A.) between 1969 and 1976. It has been investigated and exploited by Turkish Coal Enterprises (T.K.I.) since 1976. Prospection studies begun in this basin in 1940. Detailed geological studies had been carried out in 1959 and 1965 years. In total, 191 boreholes were drilled, 93 of them in 1968, and the remaining 98 in 1975.

This borehole study has been done on the mining operation boreholes. The aim of this study is to determine the economic value of the Orhaneli coalfield.

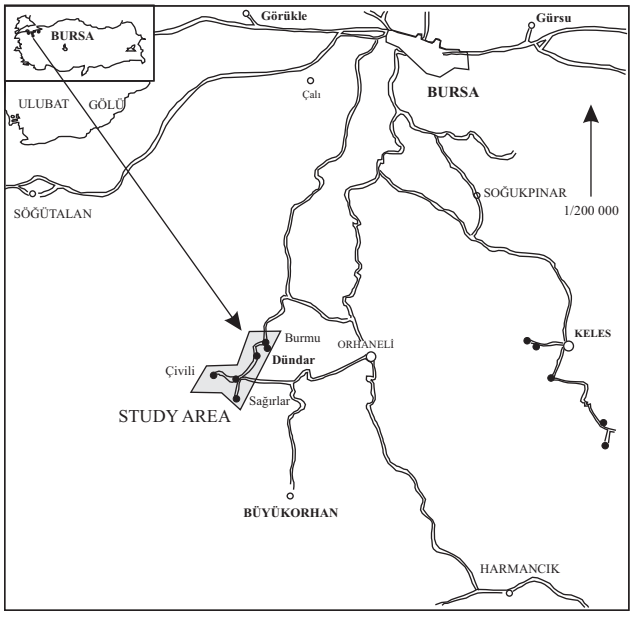

Fig. 1. Location map of the Orhaneli coalfield

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Proven and mineable reserves were calculated by polygon and isopach methods in the Orhaneli coal field, for Burmu, Sağırlar and Çivili sectors based on the boreholes drilled in various years. Average content of moisture, ash, volatile matter, fixed carbon, total sulphur, and lower calorific values were determined in the raw coal and in the air dried coal for every borehole, and then for the whole sector.

Overburden ratios were found for all of the three sectors, and the boundaries were drawn for open-pit and underground mining methods.

Coals, which have been exploited in the Orhaneli coal field, have been used in thermal power plants, industry, and domestic heating.

Study area is located in the west of Orhaneli, in the Bursa province, and covers the area between Burmu, Dündar, Çivili, and Sağırlar villages (Fig. 1). Coal bearing sectors lie along the SW–NE direction. Burmu sector is to the north, and Çivili is to the west of Sağırlar.

GEOLOGY

Neogene aged coal bearing limnic sediments lie in the western Anatolia unconformably on the crystalline metamorphic substratum. The Miocene aged lignites are generally located in fault bounded basins in the western Turkey. There is no tectonic problem in the Orhaneli basin.

The sectors of Burmu, Sağırlar, and Çivili, in the northwest of Orhaneli, show similar stratigraphic sequences (Fig. 2).

Formations are classified as pre-Neogene, Neogene, and post-Neogene (M.T.A., 1976). The basement is made up of Palaeozoic aged metamorphic schist, marble, and Upper

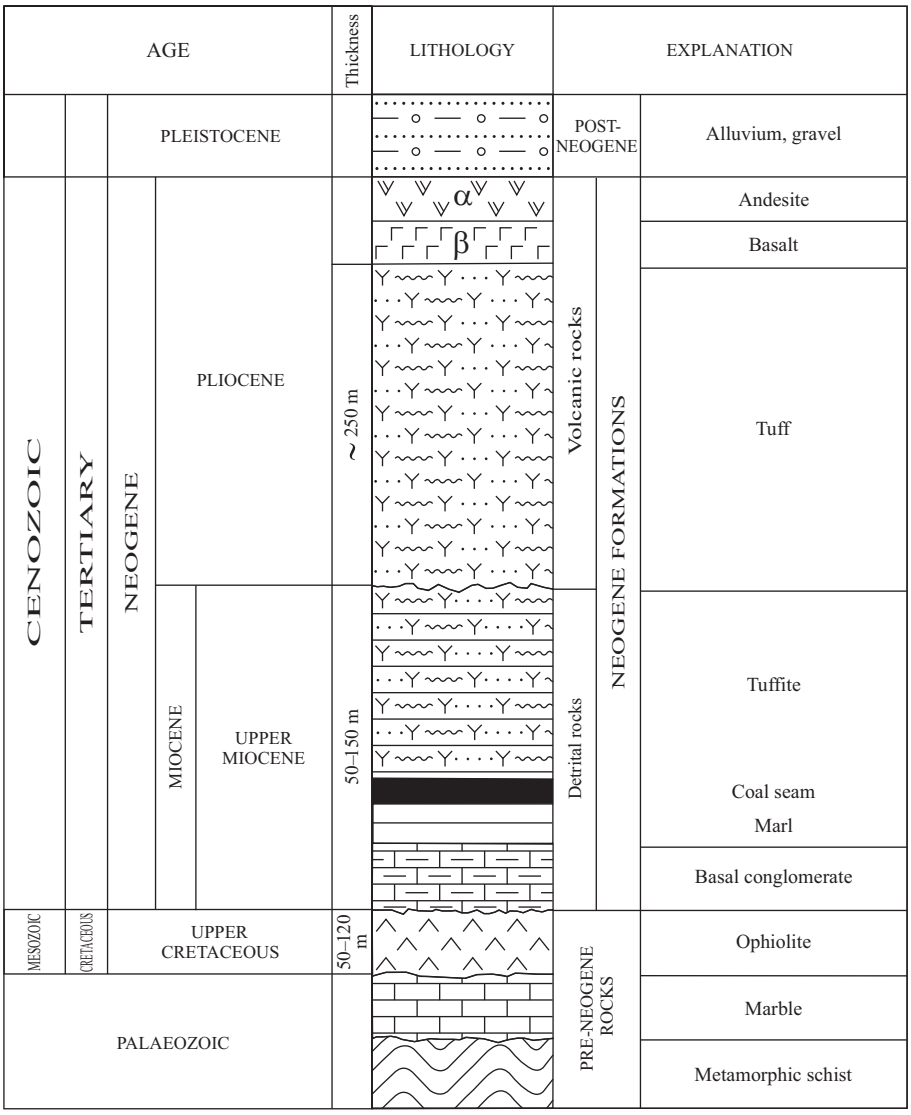

Fig. 2. Schematic stratigraphic section of the Orhaneli coalfield (after M.T.A., 1976)

Kratese aged ophiolites being the pre-Neogene formations. Neogene formations overlie discordantly the basement rocks and consist of diacritical rocks at the base, and volcanic rocks at the top. Upper Miocene aged diacritical rocks begin with basal conglomerate and end with coal bearing marl and tuffite. Thickness of basal conglomerate varies between 5 and 6 m and reaches 120 m in the middle part of the basin. Coal bearing marls and tuffites overlie the basal conglomerate concordantly.

The age of the marls were determined as Upper Miocene by mammalian fossils found in the coal seam (*op. cit.*). Neogene volcanics are in the base and lava flows at the top. Thickness of Pliocene aged tuff reaches 250 m. Lava flows are not observed in the Burmu sector but cover large areas in the Sağırlar and Çivili sectors. Post-Neogene rocks are represented by Pleistocene gravels and valley filling alluvia.

BURMU SECTOR

Alltogether, 94 (reserve) boreholes were drilled in the Burmu sector. Among these boreholes only 69 cut mineable coal seam and were used in our calculations.

Total coal-bearing area covers 3,820,698 m^2, excluding the area still being mined (Table 1). The proven reserves were determined at 39,647,871 tonnes, mineable reserves — at 31,458,767 tonnes, by polygon method (for the area to be mined in the future). Coal reserves were found by isopach method to be 38,222,734 tonnes.

Table 1

Reserves and overburden of Burmu sector

Values	Unit	Total reserves	Open-pit mine	Underground mine
Total area	m^2	3,820,698	2,657,923	1,162,775
Mineable seam thickness	m	6.74	8.12	3.32
Proven reserves	tonnes	39,647,871	33,139,169	5,826,233
Mineable reserves	tonnes	31,458,767	26,674,054	4,281,913
Overburden thickness	m^3	114.10	112.60	117.7
Intercalation thickness	m	1.30	1.42	1.09
Overburden	m^3	436,159,930	299,341,972	136,934,236
Intercalation overburden	m^3	4,982,437	3,777,431	1,264,211
Total overburden	m^3	441,142,367	303,119,402	138,198,448
Overburden ratio	m^3/tonnes	14.02	11.36	32.27

Overburden and intercalation of barren rock were calculated by polygon method for every polygon and then for the whole area. An overburden of 436,159,930 m^3 and an intercalation of 4,982,437 m^3 were calculated in the Burmu sector. An average overburden ratio was found to be 14.02 ton/m^3 for the whole sector.

Overburden ratio was accepted as 1/20 ton/m^3 for determining open-pit and underground mining boundaries. 26,674,054 tonnes mineable reserves will be excavated by the open-pit mining method, and 4,281,913 tonnes by the underground mining method.

The chemical analysis results have been given in Table 2 both for the total area and for open-pit and underground mining areas in the Burmu sector. As one can see on this table, there are no important differences between open-pit and underground mining areas.

Table 2

Average chemical analysis values of Burmu sector

Chemical analysis values		Total reserves		Open-pit mine		Underground mine	
		raw coal	air dry coal	raw coal	air dry coal	raw coal	air dry coal
Moisture	%	27.39	8.80	27.15	8.77	29.13	9.35
Ash	%	26.48	29.29	26.11	27.76	23.15	28.46
Volatile matter	%	29.18	35.49	29.44	35.59	28.02	35.11
Fixed carbon	%	24.52	31.76	24.86	32.35	23.24	29.51
Total sulphur	%	1.84	2.42	1.76	2.35	2.14	2.69
Lower calorific value	kcal/kg	2622	3676	2661	3780	2690	3645

SAGIRLAR SECTOR

Alltogether, 43 (reserve) boreholes were drilled in the Sağırlar sector. Among these boreholes only 29 cut coal of mineable thickness and were used in our calculations.

Total coal-bearing area covers 1,358,475 m^2, excluding the area still being mined (Table 3). The proven reserves were determined at 8,669,752 tonnes, mineable reserves at 6,632,182

Table 3

Reserves and overburden of Sağırlar sector

Values	Unit	Total reserves	Open-pit mine	Underground mine
Total area	m^2	1,358,475	559,975	798,500
Mineable seam thickness	m	4.14	5.37	3.28
Proven reserves	tonnes	8,669,752	4,604,899	4,064,853
Mineable reserves	tonnes	6,632,182	3,631,310	3,000,875
Overburden thickness	m^3	107	91.3	118.1
Intercalation thickness	m	—	—	—
Overburden	m^3	145,476,921	51,161,017	94,315,903
Intercalation overburden	m^3	—	—	—
Total overburden	m^3	145,476,921	51,161,017	94,315,903
Overburden ratio	m^3/tonnes	21.94	14.09	31.43

tonnes by polygon method for the area to be mined. Coal reserves were found by isopach method to be 9,514,095 tonnes.

Overburden and intercalation of barren rock were calculated by polygon method for every polygon and then for the whole area. An overburden of 145,476,921 m^3 was established in the Sağırlar sector. There are no intercalations in this sector.

Table 4

Average chemical analysis values of Sağırlar sector

Chemical analysis values		Total area		Open-pit mine		Underground mine	
		raw coal	air dry coal	raw coal	air dry coal	raw coal	air dry coal
Moisture	%	24.47	10.41	24.59	9.54	24.26	12.07
Ash	%	24.57	26.99	24.84	25.39	18.84	21.12
Volatile matter	%	29.44	34.07	31.52	34.97	26.94	33.39
Fixed carbon	%	29.52	36.03	29.35	36.04	29.71	36.02
Total sulphur	%	2.47	3.06	2.47	3.12	2.47	2.99
Lower calorific value	kcal/kg	3032	3938	3027	4027	3360	4282

There is only one coal seam. An average overburden ratio was calculated at 21.94 m^3/ton for the whole sector.

Overburden ratio was accepted as 1/20 ton/m^3 for determining open-pit and underground mining boundaries. 3,631,310 tonnes mineable reserves will be exploited by the open-pit mining method and 2,712,168 tonnes by the underground mining method.

The chemical analysis results have been given in Table 4 both for the total area and for open-pit and underground mining areas in the Sağırlar sector. As one can see on this table, there are no important differences between open-pit and underground mining areas.

ÇIVILI SECTOR

Alltogether, 54 (reserve) boreholes were drilled in the Civili sector. Among these boreholes only 30 cut coal of mineable thickness and were used in our calculations.

Total coal-bearing area in this sector covers 3,820,698 m^2, with no mining operations until now there (Table 5). The proven reserves were determined at 12,559,456 tonnes, mineable reserves at 9,217,457 tonnes, by polygon method for the sector to be mined. Coal reserves were calculated by isopach method at 11,439,763 tonnes.

Overburden and intercalation of barren rock were calculated by polygon method for every polygon and then for the whole area. Overburden of 271,726,453 m^3 and an intercalation of 7,127,797 m^3 will be dealt with in the Çivili sector. An average overburden ratio for the whole sector is found to be 30.25 m^3/ton. Overburden ratio was accepted at 1/20 ton/m^3 for determining open-pit and underground mining boundaries. 3,330,824 tonnes mineable reserve will be produced by the open-pit mining method and 5,231,336 tonnes by the underground mining method.

The chemical analysis results have been given in Table 6 both for the total area and for open-pit and underground mining areas in the Çivili sector. As one can see on this table, there are no important differences between open-pit and underground mining areas.

Table 5

Reserves and overburden of Çivili sector

Values	Unit	Total reserves	Open-pit mine	Underground mine
Total area	m^2	2,200,050	623,600	1,576,450
Mineable seam thickness	m	3.62	4.52	3.02
Proven reserves	tonnes	12,559,456	4,482,568	7,177,962
Mineable reserves	tonnes	9,217,457	3,330,824	5,231,336
Overburden thickness	m^3	123.51	49.7	152.7
Intercalation thickness	m	3.24	5.23	2.50
Overburden	m^3	271,726,453	31,037,844	240,846,254
Intercalation overburden	m^3	7,127,797	3,259,274	3,937,518
Total overburden	m^3	278,854,249	34,297,118	244,783,772
Overburden ratio	m^3/tonnes	30.25	10.30	46.79

Table 6

Average chemical analysis values of Çivili sector

Chemical analysis values		Total area		Open-pit mine		Underground mine	
		raw coal	air dry coal	raw coal	air dry coal	raw coal	air dry coal
Moisture	%	22.66	5.51	23.96	6.57	21.54	7.24
Ash	%	44.39	54.18	44.46	54.62	40.51	58.78
Volatile matter	%	18.52	21.83	18.57	23.00	18.50	21.33
Fixed carbon	%	23.87	28.10	26.15	32.20	22.91	26.37
Total sulphur	%	2.64	2.90	2.95	3.56	2.45	2.62
Lower calorific value	kcal/kg	2010	2483	2012	2564	2260	2743

RESULTS

Taking the mining operations carried out so far into consideration, if we accept the overburden ratio 1/20 tonnes/m^3 as the limits for mining methods, it has been determined that in the Orhaneli coal field remain in total 45,861,605 tonnes of mineable reserves, 33,636,188 of which being within the range of an open-pit and 12,225,417 foreseen for underground mining. The percentage of moisture in the coal for open-pit mining is 23.96–27.15%, ash 24.84–44.46%, volatile matter 18.57–31.52%, fixed carbon 24.86–29.35%, total sulphur 1.76–2.95%, and lower limits of the calorific value to be 2012–3027 kcal/kg in the original coal.

Total mineable reserves for underground mining have been determined at 12,225,417 tonnes, with 21.54–29.13% of moisture, 18.84–40.51% of ash, 18.50–28.02% of volatile matter, 22.91–29.71% of fixed carbon, 2.14–2.47% of total sulphur, with a lower limits of calorific value at 2260–3360 kcal/kg in the original coal.

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