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Lignite resources of Turkey: Geology, reserves, and exploration history

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ABSTRACT

This article aims to emphasize the importance of lignite, which is the mostly used domestic energy source in the Turkish energy mix, by briefly overviewing its geology, reserves, and exploration. Lignites are distributed in mostly continental sedimentary basins of Tertiary age all over the country. The lignite-bearing basins display the characteristics of different geological settings, of which grabens and half-grabens are the most common ones especially in western Anatolia. The geological and chemical characteristics of Turkish lignites do not only create some important problems during mining and coal preparation but also make them unfavorable for consumption. However, since they are the most valuable energy resource of the country they should benefit the economy in the most efficient and environmentally friendly way. Moreover, two most important conclusions of this study are as follows: firstly, reserve estimation practices in the country should definitely be revised to provide a more realistic evaluation of the country's lignite potential for developing medium- and long-term energy strategies and policies for decision- and policy-makers. Secondly, exploration and development activities should be coordinated by a single institution, most likely a government institution, as has been the case for some 50 years.

1. Introduction

As the major indigenous energy source of the country, lignite, constituting up to 20.9% in 1986 of the energy mix of Turkey, has always been very important. Recently, although its share is increasing from a historical minimum of 10.2% in 2005 to 14% in 2012, the share of hard coal has almost doubled by increasing from 8.8% to 16.7% between 1978 and 2012, making it more important than lignite. However, lignite is the biggest national energy resource whereas hard coal is import-dependent at the rate of 94.7% by 2012. This is a very controversial policy for a country whose dependency on foreign energy sources has already reached 75.9% by 2012. This article, therefore, attempts to emphasize the importance of lignite as the major domestic energy source in the Turkish energy mix by briefly overviewing its geology, reserves, and exploration.

The upstream sector of the Turkish lignite industry is traditionally dominated by state-owned enterprises, such as the General Directorate of Mineral Research and Exploration (MTA), the General Directorate of Turkish Coal Enterprises (TKİ), and Electricity Generation Company (EÜAŞ). However, while TKİ and EÜAŞ are responsible for lignite production and electricity generation from lignite, MTA was established to conduct reconnaissance, appraisal, and exploration activities for coal among other minerals. For this reason, most research and exploration activities, including geological mapping, geochemical analyses, geophysical studies, exploratory drilling, etc. have been carried out by MTA since its establishment in 1935. However, after the establishment of TKİ in 1957 and TTK (Turkish Hard Coal Enterprises) in 1983, some of MTA's duties have been transferred to these enterprises. After it was delegated responsibility for the lignite fields feeding coal-fired power plants, EÜAŞ became not only the second biggest lignite producer after TKİ, but also the public company with the largest lignite reserves in Turkey especially after 2005.

Since TKİ has historically been the major lignite supplier to industry, this study concentrates on its reserves and upstream activities. The relevant activities of other state-owned enterprises and private companies are also included wherever data is available. The data presented in this study is mostly obtained from TKİ within the framework of the project "History of Turkish Coal Enterprises (TKİ) and Turkish Hard Coal Enterprises (TTK), and Turkish Coal Strategies". Other data including previous reports and publications are also used in various extents. Therefore, unless otherwise stated the data is from Ediger (2014).

Although they can also be traced back to the late 19th century, modern and well-documented lignite exploration activities started in the 1970's as summarized in TKİ (1973). From this perspective, *Lignite Inventory of Turkey* published in 1986 has been a milestone as far as geology and reserves of Turkish lignites are concerned. The report

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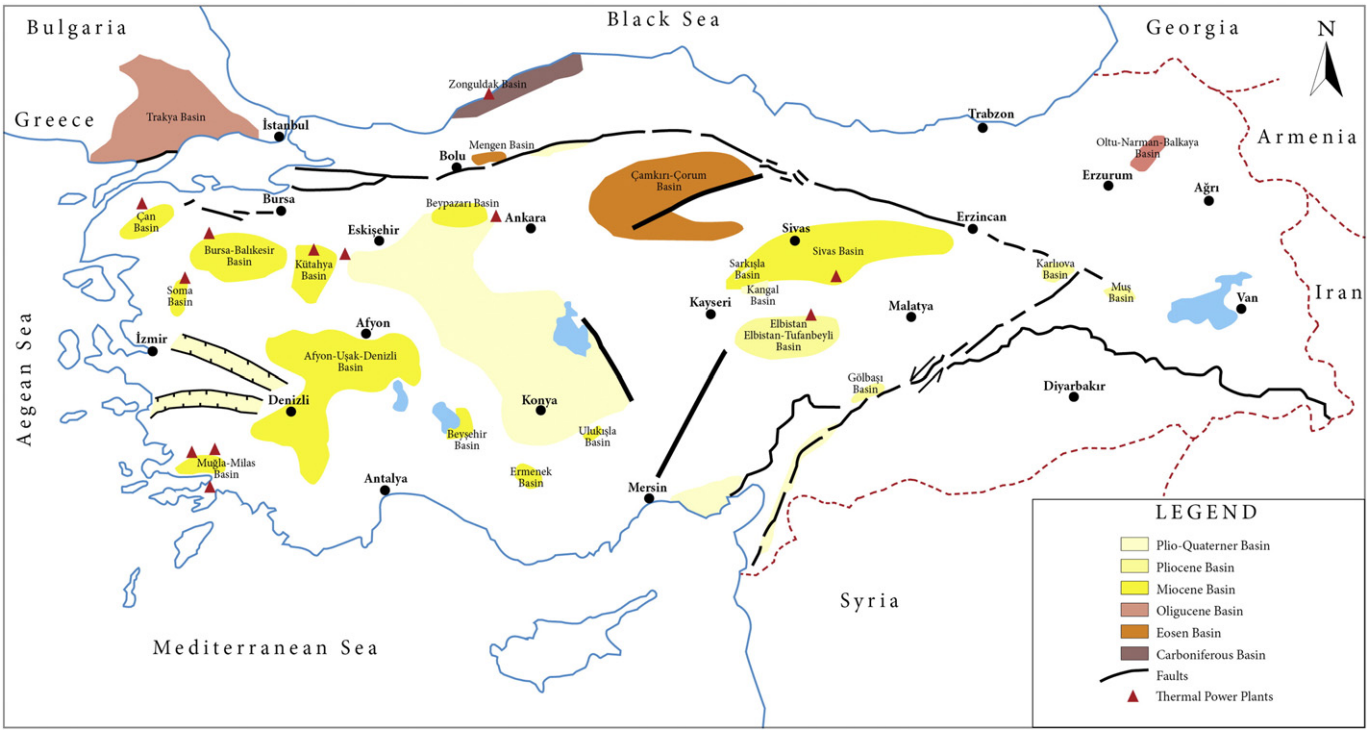

Fig. 1. Coal basins of Turkey. Compiled from the Map of "Tertiary Coal Basins of Turkey" prepared by MTA[2]

[2] Available at: http://www.mta.gov.tr/v2.0/daire-baskanliklari/enerji/images/siteharitalar/5.jpg. Access date: 23.12.2013.

prepared by a special commission established in MTA compiles all previous studies and evaluates a total of 133 lignite occurrences in Turkey systematically (MTA, 1986). Data presented in this report and in its revised forms has been used by policy makers and investors for many years.

The second important year in terms of lignite exploration was 1993. MTA revised its inventory (MTA, 1993), and MTA and TKİ geologists presented several papers in the *Symposium on Our Lignite Sector Towards the Years 2000's* organized by the Turkish Chamber of Mining Engineers (TCME, 1994). Finally and more current, MTA revised its inventory for the third time (MTA, 2010); TKİ published its *Lignite Sector Report* (TKİ, 2011), and Ünalan (2010) summarized all available data in a MTA book entitled *Coal Geology*. Meanwhile, a group of MTA geologists headed by Ertem Tuncalı compiled all previous data in a book entitled *Chemical and Technological Properties of Tertiary Coals of Turkey* (Tuncalı et al., 2002). In addition to all these, "Lignite Exploration Project" conducted by MTA achieved great success with new field discoveries and huge reserve additions in 2008 and 2009. Continuing these exploration activities would be beneficial for further discoveries of lignite-bearing basins of Turkey.

The structure of this article is as follows: Section 2 reviews the geographical and geological setting of major lignite basins of Turkey and the physical and chemical properties of Turkey's lignites are also given in this section. In Section 3, classification and historical development of reserves are thoroughly studied together with some international applications of the reserve concept. The details of exploration and development activities are the subjects of Section 4. Finally, Section 5 concludes and makes some suggestions for further studies.

2. Geological setting of lignite basins

Although bituminous coals are found mostly in the paralic Zonguldak basin of Carboniferous age in the western Black Sea coast of Turkey, lignites are distributed mostly in continental sedimentary basins of Tertiary age all over the country (Fig. 1).[1] These lignites also contain very little amounts of subbituminous coals.

The lignite basins cover an area of 110,000 km^2 of which 2% is Eocene, 6% is Oligocene, 41% is Miocene, and 51% is Pliocene in age. They are distributed in wide geographic areas, especially in Central Anatolia (558.9 km^2), Aegean (345.3 km^2), Thrace Basin (219.8 km2), and East Anatolia (184.9 km^2) in Turkey (Tuncalı et al., 2002). The lignite seams in these basins are mostly of Paleogene (Eocene and Oligocene) and Neogene (Miocene and Pliocene) age. Some small seams exist in Jurassic strata in the Gümüşhane, Bursa, and Adana regions and in Cretaceous strata in the Bursa and Artvin regions (Şengüler, 2010; Tuncalı et al., 2002; Ünalan, 2010). The maximum depths and ranges of thicknesses of lignite seams in Turkey vary significantly among different basins: 605 m and 0.35–14.90 m in Eocene basins, 332 m and 0.05–5.10 m in Oligocene basins, 828 m and 0.10–57.00 m in Miocene basins, and 426 m and 0.10–87.00 m in Pliocene basins, respectively (Tuncalı et al., 2002).

The lignite-bearing basins display the characteristics of different geological settings (A. I. Okay, 2014, pers.comm.; Görür and Okay, 1996; Şengüler, 2010; Turgut et al., 1991) but the most common basins are the grabens and half-grabens, which were formed in the Aegean Region as a consequence of the westerly escape of the Anatolian continent during Neogene (e.g., Barka et al., 1994; Ediger and Tuna, 1993). Lignite seams are mainly formed together with volcano-clastics and carbonates, which were deposited in lacustrine and fluviatile environments in those tectonically-active basins. One of the most important features of these basins is the association of organic matter deposition with volcanic activity (Ediger, 1990). However, the volcanic heat impact was

[1] Some very limited occurrences of bituminous coals also exist in addition to the Zonguldak basin in the Eastern Pontides (Mann et al., 1998) and in the Eastern Taurids (Korkmaz and Gülbay, 2007).