Economics of Boron Mining in Turkey

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Abstract: Boron minerals are one of the most important richness of Turkey. Turkey has a great potential in boron minerals regards to the reserves and the quality of these minerals. Boron minerals have an intensive and increasing usage ranging from glass to detergent industry and in metallurgical, agricultural and nuclear applications. Despite the important potential, Turkey gains only an average of 300 million US Dollars per year. Therefore, this income should be increased proportionally to the potential. In this study, production and export of ETİBOR A.Ş. since 1978, future targets are reviewed.

Introduction

Boron, which has the world's most common application, is one of the most important elements. This is why the industry is one of the most important foundation stones. Boron minerals are structures in different proportions of boron oxide (B_2O_3) which are naturally formed. There are over 200 naturally occurring boron containing minerals which have major commercial importance; tincal, colemanite, kernite, ulexite, pandermite, boracite, szaibelyite and hydroboracite (Table 1). Boron minerals in Turkey, which are widely available, are tincal, colemanite and ulexite. These minerals are sodium, calcium and sodium+calcium boron-based compounds. First of these minerals can be physically processed enriched (concentrated boron) can be refined later converted to a variety of boron chemicals (Köse et al., 2002).

Mineral	Chemical composition	% B_2O_3	Production Place
Tincal (natural borax)	$Na_2B_4O_7$.$10H_2O$	36.5	Kırka, Emet, Bigadiç, A.B.D
Kernite (rasortie)	$Na_2B_4O_7$.$4H_2O$	51.0	Kırka, A.B.D., Argentina
Ulexite (boronatrocalcite)	$NaCaB_5$ O_9 .$8H_2O$	43.0	Bigadiç, Kırka, Emet, Argentina
Probertite (kramerite)	$NaCaB_3O_9$.$5H_2O$	49.6	Kestelek, Emet, A.B.D
Colemanite	$Ca_2B_6O_{11}$.$5H_2O$	50.8	Emet, Bigadiç, Küçükler, A.B.D
Priceite (pandermite)	$CaB_{10}O_{19}$.$7H_2O$	49.8	Sultançayır, Bigadiç
Boracite (stassfurite)	$Mg_3B_7O_{13}Cl$	62.2	Germany
Szaibelyite (ascharite)	$MgBO_2OH$	41.4	B.D.T. (Old S.S.C.B.)
Hydroboracite	$CaMgB_6O_{11}$.$6H_2O$	50.5	Emet

Table 1: Boron mineral which are commercially important [2]

Boron is consumed mostly in the form of boron chemicals. Moreover, the concentration of boron can be consumed directly. Boron products are used in many areas including aerospace and aircraft, nuclear applications, military vehicles, fuel, electronics and communications industry, agriculture, glass industry, chemical and detergent industries, ceramic and polymeric materials, nanotechnology, automotive and energy sector, metallurgy and construction. Nearly 75% of boron products are consumed in glass, ceramic, agriculture and detergent industry (Figure 1).

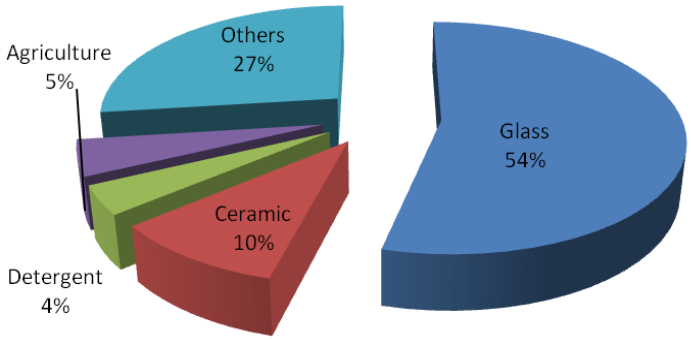

Figure 1. World Boron Consumption in Sectors

The important boron deposits are located in Turkey, USA and Russia. Turkey has 72 percent of world reserves of boron (Table 2).

	Total Reserve	**Percent in Total (%)**
Turkey[1]	866,000	72
USA[2]	80,000	7
Russia[2]	100,000	8
China[2]	47,000	4
Chile[3]	41,000	3
Bolivia[3]	19,000	2
Peru[2]	22,000	2
Argentina[2]	9,000	1
Serbia[5]	16,200	1
Iran[2]	1,000	0
Kazakhistan[4]	-	-
TOTAL	**1,201,200**	**100**

Table 2: World Boron Reserve ($x10^3$ Ton - B_2O_3) [Boron Sector Report 2009]

1. 1. Eti Mine reserves information was used in 2006.
2. USGS Mineral Commodity Summariers, January 2009, was taken.
3. USGS Mineral Commodity Summariers, January 2002, was taken.
4. Satimola region of Kazakhstan on the basis of reserves of 102 million tonnes B_2O_3 at www.borates.co.uk is given as the other sources are given very different and contradictory figures, these figures reflected in the table. Given this value is 67 percent of ETI shares.
5. http://www.riotinto.com/whatweproduce/17056_inferred_resource_at_jadar_lithium_project.asp

The borate deposits known in Turkey are especially located in Eskişehir-Kırka, Balıkesir-Bigadiç, Bursa-Kestelek, and Kütahya-Emet (Figure 2). From two main ores, tincal and colemanite, boron and boron compounds are obtained. The important tincal deposits are in Kırka while the colemanite deposits are around Emet and Bigadiç. Ulexite is located in Bigadiç. Since the boron minerals in Turkey are only run by Eti Mine Works General Management. Eti Mine's operating base consists of five competitive mining operations: Kırka, Emet, Bigadiç and Kestelek (Table 3).

Production Place	Natural Borates	Total Reserve (Million Ton)	Grade $\%B_2O_3$
Kırka, Eskişehir	Tincal	750,620	26
Bigadiç, Balıkesir	Colemanite, Ulexite	623,459	29-31
Emet, Kütahya	Colemanite	1,682,562	28-30
Kestelek, Bursa	Colemanite	6,995	29
TOTAL		3,063,636	

Table 3: Turkey Boron Reserves and Types [BOREN web pages, 2010]

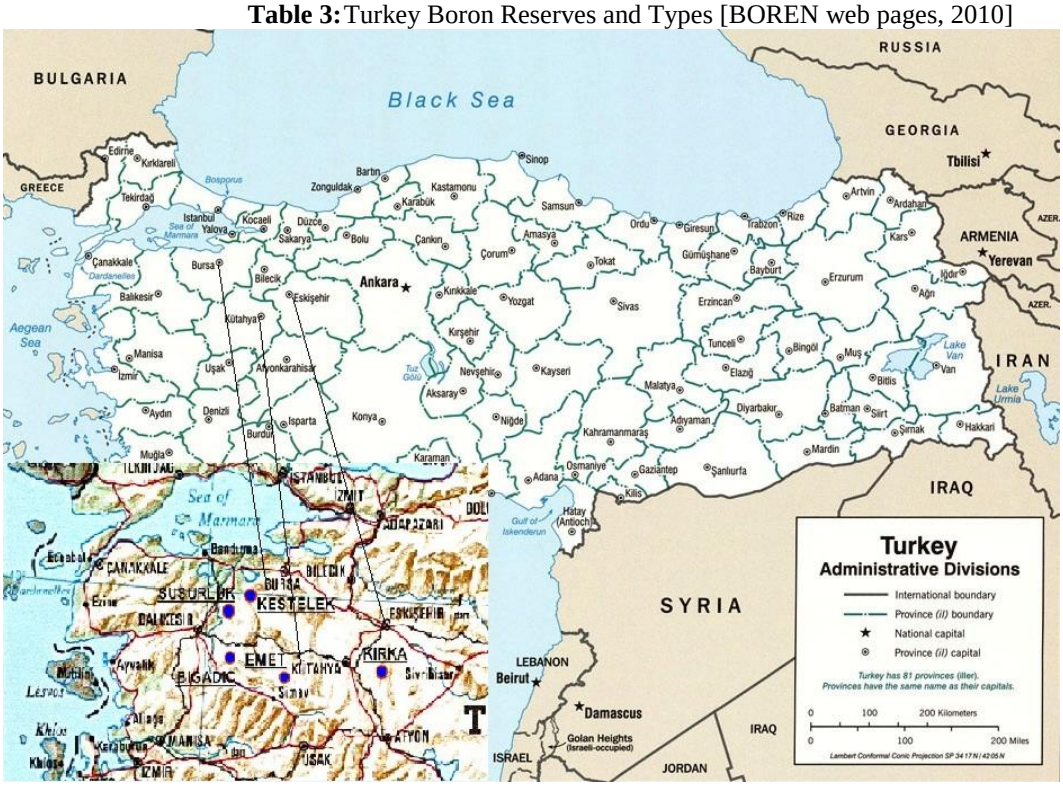

Figure 2: Sources of boron distribution in Turkey

Trade of Turkey's Boron Products

Turkey owns the biggest and highest quality boron reserves in the world. Turkey is the largest boron producer and seller of the world. The entire boron demand in the domestic market is met. The most important countries in the world production of boron are Turkey, USA, Argentina, Russia, China, Chile, Bolivia and Peru. In 2008, global boron production was about 1.91 million tons of B_2O_3. The production of these countries is given in Table 4 (BOREN web pages, 2010).

Countries	**Market ratio (%)**
Turkey	**42**
USA	**35**
Chile, Argentina, Bolivia and Peru	**11**
Russia and China	**12**

Table 4: Position of Turkey in World Boron Market

Boron ore in the country is converted to concentrated boron (colemanite, ulexite, Tincal) and refined boron (boric acid, borax pentahydrate and borax decahydrate) products are sold to domestic and foreign markets. Boron concentrate production is done in Emet Kestelek and Bigadiç. Refined boron products are made in Kırka Bandırma and Emet (EMW, 2009).

In Turkey, selling high value-added product (boron chemicals and equivalent) was identified as the main policy. As a result, while reducing the share of exports concentrated boron, increasing constantly share of boron chemicals and equivalent products. In 1998, 53 percent of total sales consisted of the sales of concentrated boron and 47 percent of total sales consisted of from the sales of boron chemicals and equivalent boron (Figure 3).

In 2009, 96 percent of Turkey's total borax products sales revenue consisted of foreign sales. Borax pentahydrate has the highest share in boron chemicals exports. Boric acid is the second coming one. Covering the period 2002-2009 in Turkey concentrated boron and boron chemicals and equivalent products export sales are given in Figure 4 (EMW, 2008).

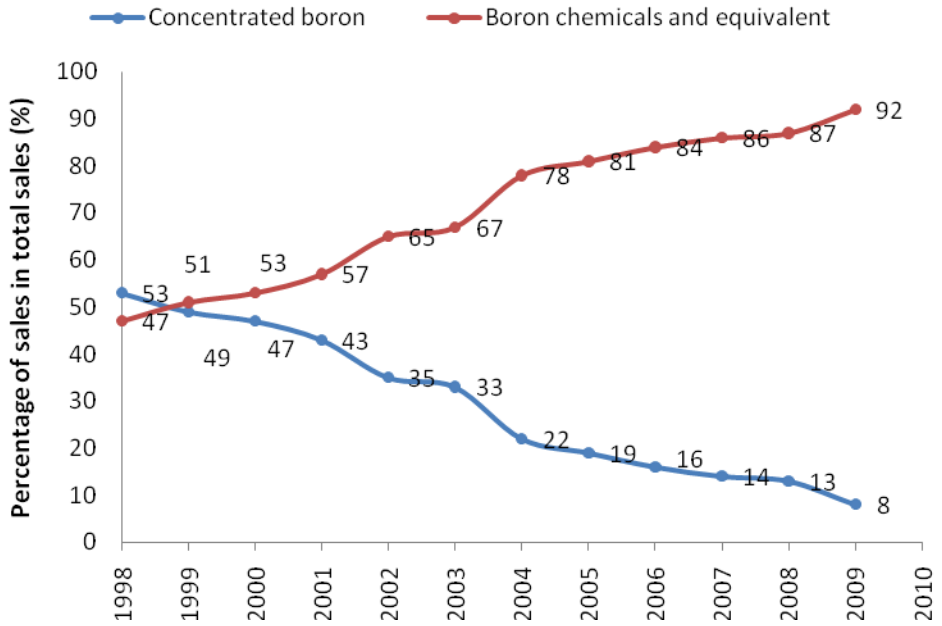

Figure 3. Concentrated boron and boron chemicals and equivalent products sales of percentage in total sales

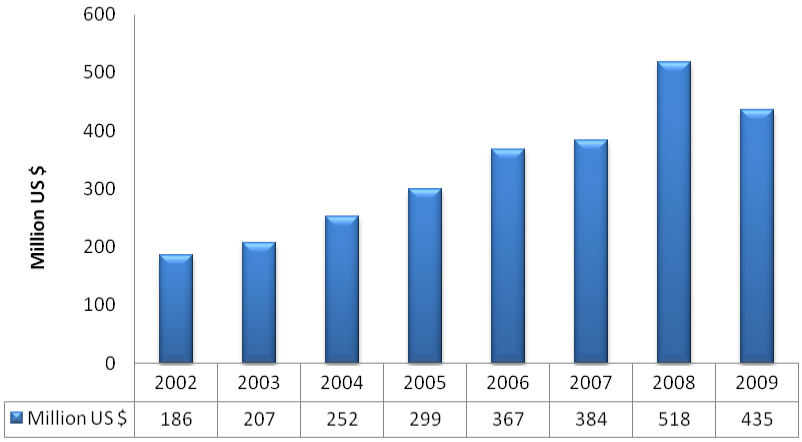

Figure 4. Turkey Concentrate Boron, Boron Chemicals and Equivalent Products Exports (as the value US$)

Conclusions

Boron ore is easily and economically obtained in Turkey. Even the B_2O_3 grade of boron stored in waste dams is higher than the B_2O_3 grade in lake waters of world's locomotive countries. For this reason, high grade and easily mineable boron ores make Turkey an advantageous country.

While the boron market share of Turkey in the world during 1980's was 25% in terms of production, it has been achieved as 37 % in the year 2009.

As Turkey and USA meet the boron demand of the world at a rate of 65-70 %, in the forthcoming years countries like Russia, China, Chile and Argentina have begun to take share in the international boron market. In the year 2009, Turkey has met the need at a rate of 37 % whereas USA met the need at a rate of 28 %. On the other hand, Turkey has sustained its leadership in the past year which it gained back in 2005.

The total sale income of Turkey from boron products in 2009 was achieved as 451 million US$, 435 million US$ of which were in the form of export. The sale income of exported boron chemicals and equivalence has increased by 232 % when compared to 2002 and happened as 402 million US$.

The revenue of world boron market is 1.5 billion US $ annually. Turkey, which owns 72% of the world boron reserves, get revenue of an average of 300 million US $. Turkey aims to increase its capacity and profit with the help of new investments.

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