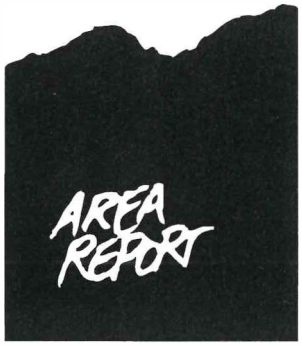

Turkish mining potential and role in the national economy

By Yavuz Aytekin and Uner Ipekoglu

In terms of reserves, Turkey's mineral resource potential is considerable and diverse. Although many of the deposits are small by world standards, in terms of boron minerals, celestite, pumice, zeolite and marble Turkey has very large reserves and in the production of boron and celestite Turkey is one of the leading countries in the world. The mining sector also plays a principal role in the national economy.

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The history of mining in Turkey goes back to ancient times. Data relating to the oldest exploration and use of mines in Anatolia dates back to the year 6 000 BC.

Although mining activity in Anatolia is so old, Turkey's present-day mining sector was not shaped until 1935. As part of the efforts to enhance and reorganise Turkish economy during the early phase of the Republic, a major push was given to the mining sector. As a result, two state-owned mining companies, the State Mineral Research and Exploration Institute (MTA) and Etibank, were established. MTA was assigned with the task of mineral exploration and research while Etibank, with the task of developing and operating the country's mineral resources, was to generate and distribute electricity and other raw materials that are required by the industry.

The performance of these tasks eventually became too burdensome for Etibank. Therefore in 1955, the Divrigi iron ore mines were transferred to a new foundation, Turkish Iron and Steel Enterprises (TDCI). In 1957 coal production was transferred to the Turkish Coal Enterprises (TKI) and 1970, the electricity generating and distributing system was shifted to the Turkish Electricity Enterprises (TEK).

History of mining in Anatolia

The history of mining in our country can be traced back to ancient times. Today it is commonly known that Hittites and Etis, two of the major civilisations which flourished in this land, had substantially developed mining and quarrying. Data relating to the oldest exploration and use of mines in Anatolia dates back to the year 6 000 BC. There were indications during the excavations at Bogazköy that about 2 000 years BC, an Egyptian pharaoh had ordered iron from the Hittite King.

Several metals were identified as in use during the Copper and Bronze Ages. These were gold, silver, copper, lead, tin, zinc, mercury and iron. The Eti period, which covered the years 2 000 to 1 200 BC, marked the peak of the Anatolian mining advancement. The first ever mining licence was granted for the present day Gumushaciköy lead deposits in that period.

It is quite certain that copper mining had also been practised in Anatolia which had witnessed the transformation from Bronze Age to that of Iron. Ergani copper mine stands out as the oldest of its kind in the world.

Chronicles reveal that the bulk of silver and golden items incorporated into Egyptian and old Greek treasures were extracted in Anatolia. The golden treasures of Lydian king Croesus and Phrygian king Midas (1 000-500 BC) have gained fame through the ages.

Although written documents, are extremely rare, mining activities have continued unabated in Anatolia during the Middle and New Ages. Romans exploited meerschaum deposits near Eskisehir in Seljuki and Ottoman periods. In addition to golden and silver items, extraction of iron ore, copper, lead and sulphur had taken place. This was indispensable components of war efforts. It is known that the Kure copper mine was worked during the era of Mehmet the Conqueror. Documents show that mining had gained attention in various parts of Anatolia and later on also gold extraction and processing in Ergani and copper, lead and silver in Keban. The famous Ottoman traveller Evliya Çelebi, in his chronicles, describes the techniques used in silver processing in Gumushane. Apart from written documents, smelting slags scattered about a wide area in Anatolia, are evidence of the state of mining during and before the Ottoman period.

In later years, as a consequence of intensified contacts with the West, a diversification took place, particularly in the 19th century. Production was focused more on items like antimony, arsenic, boric acid, copper, mercury, zinc, lead, coal and coke, lignite, sulphur, magnesite, chromite, marble and emery.

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Mining Law No. 6309 was passed in 1954 in order to facilitate the promotion and supervision of exploration and mining operations. In 1964 this law was revised to meet the developing requirements of the mining industry. At the same time, a new ministry, the Ministry of Energy and Natural resources, was established to handle both the mining and the energy affairs of the country. In the 1960's a growth was recorded in mineral based industries, which stimulated exploration of raw materials. Most of the investment was realised by state enterprises. Successive governments considered the public sector involvement, the best means of ensuring a comprehensive evaluation and development of Turkey's mineral deposits. As a result of this policy, Turkey has developed integrated industries in iron and steel, aluminium, copper, zinc, cement and in other construction materials. The share of private sector capital in mining was only about a quarter of that represented by the public sector. Turkey has also developed an export industry in boron minerals and chemicals, chromite and ferro-chrome, emery, magnesite and strontium minerals.

Table 1
Reserve and Production of Important Mineral Resources of Turkey

	Reserve Mt	Potential Mt	Current Prod Mt
Energy raw materials			
Hard coal	1 300	2 000	3 100
Lignite and sub-bituminous coal	8 100	15 000	49 580
Bituminous shale	500	3 000	na
Iron and steel Industry			
Iron ore	1 100	1 500	5 500
Manganese	5	12	3
Agricultural minerals			
Phosphate (30% P_2O_5)	75	500	100
Pyrite (45% S)	–	–	250
Sulfur (pure)	1.8	5	25
Bor minerals			
Boron (B_2O_3)	730	1 000	475
Chromium			
Chromite	10	20	800
Magnetsite			
$MgCO_3$	44	170	700
Non ferrous metalic minerals			
Copper (metallic)	3.33	6.60	35
Lead (metallic)	1.43	2.66	23
Zinc (metallic)	3.97	7.97	22
Bauxite (54% Al_2O_3)	62.70	371	450
Precious metals and rare earth metals			
Gold (metallic), ton	50	67	na
Silver (metallic), ton	47	80	20
Rare earth	4	4	na
Nonmetallic industrial minerals			
Kaolin	60	140	275
Clay	300	1 600	750
Bentonite	100	240	100
Feldspar	200	400	175
Talc-pyrophyllite	20	20	30
Quartz-quartzite	5 000	5 300	660
Celestine	0.6	5	60
Pumice	1 700	1 700	2 000
Perlite	5 800	5 800	150
Barite	20	60	400
Teolite	26 000	26 000	n.a.
Trona	235	235	n.a.
Salt	400	800	1 000
Sodium sulphate	194	194	150

Source: From figures given by State Institute of Statistics and working party of the first national mining congress of Turkey 1989 and 1991
Note: na not available

Turkey. The map shows some of the towns and cities mentioned in the article and the location of major chromite and boron deposits.

The Third Five-Year Development plan[1] sought a rapid increase in the production and export of minerals by public and private sectors. But due to unfavourable economic conditions both in Turkey and abroad the objectives were not realised.

In 1980, as part of the efforts to achieve a re-orientation of the Turkish economy and to encourage foreign investment, the government set out new ideas to he mining sector. The Mining Law No. 6304 was revised and improved by Law No. 3213 in 1985 in order to make the laws comparable with modern mining legislation in other countries thus seeking to encourage Turkish and foreign private companies to participate more effectively in the development of Turkey's mineral industry.

Coal

55 per cent of the hard coal produced from Zonguldak district in Turkey has good cooking properties and therefore is totally used for metallurgical coke production. Cooking coal requirement of the steel industry is about 6 Mt and the difference which is approximately 4.6 Mt has to be met by imports. Remaining 45 percent high volatile (over 40 per cent volatile matter) bituminous coal is used for various industrial applications[2].

A large proportion of the production of coal, see Table 1, about 55 per cent, is high-ash high-moisture and low calorific value lignites and they are used as power station fuel for electricity generation. Sales in domestic market constitute about 28 per cent of the current production. One of the most important sectors in this market is house and office heating. Due to the price advantage of coal over oil and the improvements made to conventional coal-fired boiler about 15 per cent of the total lignite production is used for general industrial applications.

Some Turkish lignites, especially those of high sulphur content, create severe environmental pollution problems. Therefore about 1 Mt of coarse steam coal is imported for domestic and industrial use at certain areas to meet the requirements of the Air Quality Protection Regulations passed in 1986[3].

Iron Ore

Turkey's iron and steel production has increased almost four times since 1980 and reached an output of 8 Mt/year. Public sector is responsible for approximately 55 per cent of the country's steel production in three integrated state-owned steel plants. Private sector produces the rest in their arc furnaces utilising scrap iron.

According to the preliminary figures given for 1990 by the State Statistics Institute, 365 000 t usable ore, 4.66 Mt sinter feed and 1.0 Mt pellet feed have been supplied within the country. Total iron ore demand covering three of Turkey's four steel plants are 8.9 Mt and 2.9 Mt ore has been imported to meet this demand.

Only 140 Mt of the total crude ore reserves given in Table 1 is marketable ore and with a forecasted increase in hot metal capacity by the year 2 000, 14.5 Mt/year ore production will be required. If there is no additional exploration and production facilities created, the marketable ore reserves will have been used out by the year 2004.

Phosphate Rock

The first phosphate deposit was discovered in 1962 in the Mazidag area of South-eastern Turkey. Almost fifty deposit are known to exist with estimated reserves of 500 Mt of which about 100 Mt are considered commercially exploitable with grades averaging between 10–25 per cent P_2O_5.

Turkey's agricultural industry continues to rely heavily on imports of fertilisers to meet its needs. Fertilisers are the country's second biggest import item after petroleum.

In 1990 industry's total requirement is equivalent to 3.2 Mt of phosphate rock and it is estimated that with an annual increase of 4.7 per cent, this figure will reach approximately 5 Mt by the year 2 000. Tur-

Table 2
Boron reserves

Area of reserves	Reserve kt	Grade % B_2O_3	Boron oxide basis	Per cent of total
Balikesir-Bigadic	915 000	30-34	320 000	43.69
Kutahya-Emet	830 000	30-40	290 000	39.59
Eskisehir-Kirka	480 000	25-36	120 000	16.38
Bursa-Kestelek	7150	30-35	2 500	0.34
Total	**2 232 150**		**732 500**	**100.00**

key imports phosphate rock from Tunisia to produce phosphoric acid. Some fertiliser works imported their own needs of phosphoric acid directly.

Etibank, in addition to the existing Mazidag Phosphate Concentrate Works, with a capacity of 125 000 t/year, is about to complete South-Eastern Anatolia Phosphates project. Utilising the open-pit method, the facility is planned to produce 558 000 t/year of phosphate concentrate (30 per cent P_2O_5) by processing 1.27 Mt/year of run-of-mine ore. The Turkish fertiliser industry is also undertaking several development projects. Furthermore, the capacities of sulphuric acid and phosphoric acid plants are being increased to improve the overall capacity utilisation of the existing fertiliser plants to 85 per cent.[4]

Boron

Turkey has 63 per cent of the world's total boron reserves. Proven reserves of borax is reported at 730 Mt on B_2O_3 basis. Etibank is the country's sole boron minerals and derivatives producer and is the second largest producer of boron in the world after the United States[5]. In 1990, separated, washed or concentrated ore production was about 1.1 Mt which is equivalent to 475 000 t net B_2O_3. The boron mineral reserve distribution in Turkey is are summarised in Table 2.

Table 3
Production capacities of boron compounds in Turkey (kt)

Kirka Borax Works	
Borax pentahydrate	160
Borax decahydrate	17
Anhydrous borax	60
Bandirma Borax and Acid Factories	
Borax decahydrate	50
Borax pentahydrate	5
Boric acid	135
Sodium perborate	20
Hydrogen peroxide	15
Sulphuric acid	120

Etibank's Bigadic Mining Works Establishment produces colemanite and ulexite concentrate (250 000 t/y capacity) from the deposits found north of the town Bigadic in Balikesir province, whereas Emet Colemanite Works in Kutahya province, produces mainly colemanite concentrate (500 000 t/year capacity). Kestelek Boron Mining Works of Etibank in the province of Bursa produces arsenic free colemanite concentrate with a capacity of 100 000 t/year. The only commercial sodium borate deposit in Turkey is at the Kirka Mine between Afyon and Eskisehir provinces. Kirka Borax Works Establishment has a capacity of 500 000 t/year of tincal concentrate.

Production capacities of boron compounds of Turkey are are show in Table 3.

Boron has by far the largest share of Turkey's mineral exports. However, the export of boron derivatives is still modest, although it is expected to increase steadily in forthcoming years. According to the figures given by the State Planning Organisation in 1990, 780 000 t of separated, washed or concentrated ore and 150 000 t of boron chemicals in total were exported by Etibank.

Chromite

Turkey has always been one of the major chromite and concentrate producing and exporting countries. There are over 700 known chromite deposits in Turkey and they have generally been formed as high grade or low grade deposits of the Alpine type and can be grouped in six main areas show in Table 4.

High grade chromite reserves of Turkey constitute only 1.7 per cent of the total world reserves. However, in the years to come large scale open pit mining methods may turn Turkeys low grade chromite potential into economical deposits, thus having a larger proportion in the total reserves of the world.

Table 4
Chromite reserves

Area	Grade ($\%Cr_2O_3$)	Reserve (kt)
Elazig-Guleman (East)	20-48	10 262
Bursa-Balikesir-Kutahya-Eskisehir (Northwest)	20-45	3 608
Mugla-Denizli (Southwest)	30-48	1 013
Sivas-Erzincan-Kopdag (Northeast)	35-48	1 395
Kayseri-Malatya-Mersin (Southeast)	15-48	3 901
Karsanti-Adana (South)	5-6	192 000
Total		**212 179**

Within the last ten years Turkey's annual chromite production has been between 0.6 and 1 Mt of which about a third was consumed internally for ferrochromium, refractory brics and sodium bichromite production. Etibank is the only producer of ferrochrome in Turkey, in addition to being the largest producer and exporter of chromite. Annual capacity of Etibank is 200 000 t of lumpy chromite, 320 000 t of chromite concentrate, 100 000 t of high carbon ferrochromium, 10 000 t of low carbon ferrochromium and 66 000 t of ferrochromium silica. Apart from these plants, Turkey has two bichromite plants with 32 000 t/year of total capacity. Their chromite ore requirement is about 53 000 t annually.

Other Metallic Minerals

Demand for aluminium, refined copper, lead and zinc cannot be met by domestic production, so industry relies on imports[6].

In the aluminium industry, primary production and processing is not evenly split between the state and private sector. All primary production is carried out by Etibanks only aluminium smelter at Seydisehir, Konya. Processing takes place both in Seydisehir and in the private sector. The Seydisehir plant has a treatment capacity of 200 000 t/year alumina to produce 60 000 t/year ingot and billet, and is a significant producer of sheet and foil. Bauxite reserves are ample to meet Seydisehir's needs which is about 400 000 t/year.

Annual demand for blister copper in Turkey stands at around 70 000 t about 50 per cent of which is produced domestically by Turkey's two major copper producers: Etibank and its subsidiary, KBI (Black Sea Copper Works). KBI's two smelters, Samsun and Murgul have 40 000 t and 12 000 t blister copper capacities respectively. Ergani Copper Works of Etibank has 16 000 t of blister capacity annually. The main copper refiners are Rabak, Sarkaysan and state owned MKEK, with a total refining capacity of 90 000 t/year.

Turkey's sole primary zinc producer, Cinkur, a subsidiary of Etibank, is looking at the possibility of modifying and expanding its smelter to take sulphide as well as oxide ores. The smelter has a current capacity of 33 000 t/year zinc (although is running well below this) and is expected to increase production to 70 000 t/year, as well as building an associated lead smelter.

Etibank has not yet produced antimony in refined form but it has plans to start a smelter. Annual ore production for the country is about 50 000 t of 5 per cent Sb_2O_3 antimony ore. This production is handled by Ozdemir Antimony Co.'s 30 000 t/year capacity concentrator at Turhal, Kutahya and by Etibank's 10 000 t/year capacity concentrator at Halikoy, Izmir. Antimony reserves of Turkey are estimated as 250 000 t on antimony basis.

Etibank's Silver Works located in Kutahya started silver bullion production by the end of 1987 by cyanide leaching. The mining site contains 19 Mt of silver ore deposits with an average grade of 200 gr/t. The mine is expected to produce 1 Mt of run-of-mine ore annually and 122 t/year of silver ingots. However, due to certain technological problems particularly in the grinding circuit the production was only about 23 t in 1990.

Non-Metallic Industrial Minerals

Public and private sectors produced 1 200 000 t of crude magnesite, 217 000 t of sintered and 18 000 t of calcined magnesite in 1990. All of the output is used for refractory markets both local and abroad. The main exporters are Kumas Kutahya Manyezit Isletmeleri AS, Magnesite AS (foreign capital) and Comag Continental AS. Kumas has a total of 540 000 t/year of crude magnesite capacity from three mines in the Kutahya and Eskisehir districts. The present calcined and sintered magnesite production capacity of Turkey is over 300 000 t/year. In 1989 143 000 t crude, 124 000 t sintered and 18 000 t of calcined magnesite were exported[7].

Mine production capacity for crude barites is almost 1 Mt, which after treatment comes to a saleable production of over 300 000 t. Etibank has a capacity of 100 000 t for both crude and ground barite. The rest of the production is carried out by about ten private companies. In 1990, 380 000 t of crude barite was produced, 320 000 t of which was exported.

Celestite is produced only by a private firm, Barit Maden AS, at Sivas in central Anatolia. It is a major producer and exporter in the world. Annual concentrate (92 per cent $SrSO_4$) production capacity is 60-70 000 t. About 120 t is used domestically for electrolytic zinc production, the rest is exported. Proven reserve is 600 000 t.

Turkey has very large pumice and perlite deposits. Pumice production has currently reached 2 Mt/year. About 120 000 was exported in 1989, the rest is consumed domestically[7]. Production and exports are made only by private sector.

Etibank's Cumaovasi perlite plant, located in Izmir, meets the bulk of the country's demand. 145 000 t of crushed, screened and classified perlite, 50 000 m^3 of expanded perlite, 35 000 m^2 of separation panels, 240 000 m^2 of block bricks and 1250 t of micronised perlite are produced annually. Other firms produce crushed and screened products. Total crude perlite capacity is 200 000 t/year.

Trona was discovered in Turkey in 1979. There is only one known deposit at Beypazari near Ankara. The deposit has proven reserves of about 200 Mt with a grade of 46 per cent of soda carbonate. This deposit is considered especially important since the nearby market countries of Europe has no known natural soda deposits[8]. Etibank's Beypazari Natural Soda Directorate is trying to establish a facility to produce 750 000 t/year of soda ash. The only production in Turkey at present is synthetic soda ash from a plant owned by Soda Sanayi AS. at Mersin. total capacity is 330 000 t/year and 20 000 t/year sodium silicate.

Etibank has started to evaluate its zeolite deposits, in Bigadic area near Balikesir province it is hoped that foreign companies will be interested.

Sulphur is the second largest fertiliser mineral imported after phosphate rock. The amount of raw sulphur imported is about 138 000 t in 1988, 144 000 t in 1989 and 180 000 t in 1990. Etibank is trying to meet sulphur needs of the country by its Keciborlu Sulphur Works Establishment which has a 55 000 t/year of refined sulphur capacity. But due to a decrease in the ore production from its underground operations since 1986, the refined sulphur production is also decreasing. It was 40 000 t in 1987, 30 000 t in 1988 and 25 000 t in 1988[7]. Pure sulphur reserves of Keciborlu area is about 1.5 Mt.

Sulphur is also obtained from pyrite concentrates acquired from Etibank's Kure Copper-Pyrite Works Establishment which has a 460 000 t/year of pyrite concentrate capacity.

Turkey has approximately 100 Mt of bentonite reserves determined by MTA. The known deposits are around Tokat-Ankara-Cankiri-Kutahya-Balikesir provinces.

However, none of the known deposits is well explored but production has been steadily rising over the past ten years. Annual production is between 60 000 and 100 000 t, although capacity is around 300 000 t of crude bentonite. Baser Mining, a major barite producer, also grinds and sells bentonite for drilling and foundry applications.

Apart from a new 50 000 t/year plant, which is under construction, Samas Mining AS and Karakaya AS, have two bentonite grinding plants with production capacities of 75 000 t and 60 000 t/year respectively Bentonite export of Turkey is about 50 000 t/year.

The country has a well developed ceramics industry, which is largely self-sufficient in raw materials. Production is difficult to assess because large proportion is captively consumed by companies like Canakkale Seramik AS, Toprak Seramik AS and Eczacibasi Seramik AS. Esan, a subsidiary of Eczacibasi is, however, presently selling considerable amounts of ceramic materials on the free market, including for export. Esan's largest export is refractory clays which is about 50-60 000 t/year. The company also exports kaolin to the Near East, 40-50 000 t/year, and feldspar, 25–30 000 t/year. The total kaolin production of Turkey is given as 400 000 t/year and export figure in 1990 was 75 000 t[7].

Turkey has considerable reserves of a wide variety of marble and travertine. Some is already produced mainly as wide blocks, but an increasing amount is cut slabs. Export markets are very attractive and Turkey, with appropriate expertise, can develop a considerable marble industry in the near future. This sector has shown a steady increase since 1980, when the total export value was 4 MUSD. In 1989 the total export value was over 32 MUSD.

Conclusions

In terms of proven and possible reserves, Turkey's mineral resource potential is considerable and diverse. It is estimated that Turkey has approximately 4 000 mineral deposits. Despite the large variety of mineralisation however, most of the deposits cannot be classified as large by world standards. On the other hand, in terms of boron minerals, celestite, pumice, zeolite and marble Turkey has very large reserves and in the production of boron and celestite is one of the leading countries in the world. Turkey has about forty different kinds of minerals, thirty of which are commercially exploited presently. The mineral output is not large in terms of tonnage and value.

The mining sector plays a principal role in the national economy from the point that it is a material supplier for domestic manufacturing. Its role is further enhanced by the fact that it creates non renewable sources of energy and highly labour-intensive. The sector, apart from its basic functions, contributes heavily to metallurgy, chemical industry, machinery and equipment, engineering-consultancy services, explosives, transportation, construction, roads, irrigation etc.

The Turkish mining sector produces thirty minerals, satisfying virtually all domestic requirements. Twelve out of 19 major industrial products listed by the state planning organisation, utilise mineral-based raw materials including energy products.

At present, Turkey is dependent on imports of three crucial mineral products: crude oil, iron and steel raw material and fertiliser minerals. The substantial bill for mineral-product imports is offset to some extent by mining exports. Turkey is particularly important as a supplier to the world markets for boron products, chromite and ferrochrome, magnesite, barite, celestite minerals, and it exports a wide variety of other minerals. The share of the mining sector in total export volume varied between three and four per cent in recent years.

The mining sectors share of GNP (gross national product) is well below the world's average which was 4.84 per cent in 1970 and 9.88 in 1980. In Turkey, this share was 2.61 in 1978 and showed a steady decrease since then: in 1982 1.95 per cent, in 1986 1.92 per cent, in 1988 1.82 per cent and in 1989 1.81 per cent. According to the estimates given by the State Planning Organisation it will be as low as 1.76 per cent in 1994.

To date, Turkey has a achieved only a small percentage of its potential in mineral production, further exploration and investment in mineral industry is required to fully develop this resource. The working party of the "First National Mining Meeting of Turkey", which was held in June 1990 suggested various measures to the government for the promotion of this sector aiming at a 13 per cent share in the GNP, producing an annual value of 8 000 MUSD by the year 2 000.

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