

Graphite: A Critical Raw Material and Turkey

Raw materials and natural resources, have always a critical and strategic role not only today but also in the course of history. In fact, among the reasons for World War 1, efforts to seize Europe's coal deposits in the Alsace-Loren is said to have an important role.

Technology and industry manufacturing countries and Country groups have also recognized the increasing importance of the raw materials today and were forced to adopt measures, and develop strategies for accessing and securing the supply of these raw materials. European Union is one of the most important of them, particularly due to geographical proximity to Turkey, and Turkey's intensive economic relations with it. The EU started to act and establish an initiative called "Raw Materials Initiative" and prepared, started to developed strategies and alternate sources for 14 raw materials that they thought important and critical. These raw materials are:

Antimony	Indium
Beryllium	Magnesium
Cobalt	Niobium
Fluorspar	PGMs (Platinum Group Metals)
Gallium	Rare Earths
Germanium	Tantalum
Graphite	Tungsten

Table 1: Critical Raw Material for EU1

A similar study has been carried out by BGS-British Geological Surveys, by evaluating over 50 raw materials, by identifying critical risk index for them, and ranks them based on importance. And BGS published a list called "Risk List 2011"

Element or Element Group	Relative Supply Risk Index	Leading Producer
Antimony	8.50	China
Platinum Group Elements	8.50	South Africa
Mercury	8.50	China
Tungsten	8.50	China
Rare earth elements	8.00	China
Niobium	8.00	Brazil
Strontium	7.50	China
Bismuth	7.00	China
Thorium	7.00	India
Bromine	7.00	USA
Graphite	7.00	China

Table 2: BGS Risk List 2011²

In both studies made by EU and BGS, two important raw materials, especially for our country, are noticeable immediately;

- Antimony (in the first rank and has a higher risk index than rare earths)
- Graphite

These two raw materials are being produced and have potential to be produced more in Turkey. Now we will have a further deeper look at Graphite.



GRAPHITE AT A GLANCE:

Graphite is a natural form of carbon with the chemical formula C and is characterized by its hexagonal crystalline structure. It occurs naturally in metamorphic rocks such as marble, schist and gneiss. Actually we know graphite in our daily life very well; it was the "lead" part of a lead pencil. Other two important natural carbon forms are Coal and Diamond.

Graphite materials fit into two primary classifications :

- Synthetic Graphite
- Natural Graphite

Synthetic Graphite is an industrial end product rather than a natural resource, so we will mainly focus on Natural Graphite as it is a raw material from a natural resource. Natural graphite can be further divided into three primary types⁴;

- Amorphous Graphite
- Flake Graphite
- Crystalline Vein

Each type has characteristic properties and is formed in a unique geologic setting. But in the basis of this classification, structure of carbon element lies. As an

example Flake Graphite has a carbon structure of flaky as it is named.

Graphite has some unique specifications that makes it very important, it is :

- Excellent heat conductor
- Excellent electricity conductor
- Heat resistant (Melting Point 3927 C°)
- Chemical and Corrosion resistant
- Resistant to acids and oxidizing agents
- Lubricating

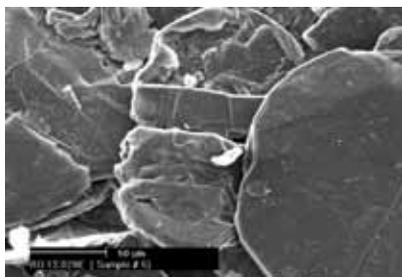
Natural Graphite are being used in many industries, these industries and shares in total natural graphite consumption are as follow⁵;

- %41 - Steel & Refractories
- %14 - Automotive Parts
- %14 - Lubricants
- %11 - Carbon Brushes
- %10 - Batteries
- %10 - Others

GRAPHITE PRODUCTION AND PRICES

Natural Graphite production is estimated around 1 million tonnes/ year, as 600,000 tonnes Amorphous and 400,000 tonnes various grade and size Flake graphite. In reality we don't have very exact and certain numbers for production quantities, mainly because Countries statistics related to production not so transparent and accessible, also production figures coming from producers which could include some speculation.

China is the biggest producers and accounting 80% of the total graphite pro-



duction worldwide. Other important producers are North Korea, Brazil, Mexico, Canada, Norway Madagascar and Sri Lanka. As I said above as we don't have very clear idea about production quantities and China's share in production, but we have very clear indicators about the market shares, when we analyze the United Nations Trade Statistics, we found out that China's share in total graphite export is a around 85%⁷. This means that China is a monopoly in the market. This situation wasn't realized for a long period of time, as there wasn't too much supply problem in the market, and graphite wasn't a hot commodity in the market because of its low price. But in 15 month periods between January 2011 and March 2012 graphite prices increased 140%⁷. To understand how graphite prices developed you can compare the prices in 2006 and 2012 in below table.

	2006 ⁸	2012 ⁹
Large Flake %94-97 C + 80 Mesh	800-950\$	2500-3000 \$
Medium Flake %90 C -80 Mesh	440-495 \$	1500-2000 \$
Amorphous Powder %80-85 C	240-260 \$	600-800 \$
Prices are CIF European Port \$/ton		

Table 3: 2006 and 2012 Graphite Prices

Prices have significantly increased after 2009, the main reasons for this increase are ; because of the crisis in 2008, producers cut back their capacity and when demand started to come back for graphite in 2009, producers were caught off guard. At the same time, China has closed down or consolidated some production, to better control environmental issues and protect graphite reserves.

Adding further pressure to prices, in January 2010, the Chinese government start-

ed going after graphite exporters that had been dodging or underpaying the 20% export tax on graphite, sending exports down and prices up. (China also has a 17% value-added tax on the material.)

Besides this, there are also very serious expectations from Lithium ion battery market. While currently small, it's the most important growth market for natural flake graphite. Lithium-ion batteries contain up to 10 times the amount of graphite as lithium, so the potential is great, especially if electric vehicles (EVs) catch on in the market. It was estimated that Lithium ion battery market could create another 1 million tonnes demand by the year 2020⁵. These expectations and price increases start a boom in graphite market, and currently over 100 graphite projects announced to the market.

But we must add a comment here, first of all it is very obvious that majority of



these projects won't be developed for next stages, and won't be even closer to production, as they are too sensitive on prices, they are very high costs projects, and for mining perspective they are logically not doable. If you look carefully you see that all of these projects are flake graphite projects, as they explained that flake graphite will be very important for new uses like Lithium batteries, but currently we don't have that size of demand, and on the other hand, it is ▶



restart their operations and occasionally produce small quantities.

Year	Production (Metric Tonnes)	Consumption (Metric Tonnes)
1985	-	4,100.00
1986	3,586.00	4,000.00
1987	8,900.00	3,400.00
1988	12,911.00	13,000.00
1989	11,000.00	12,000.00
1990	18,712.00	18,712.00
1991	26,763.00	26,763.00
1994	5,000.00	25,000*
1995	5,000.00	25,000*
1996	5,000.00	25,000*
1997	5,000.00	25,000*
1998	5,000.00	25,000*
1999	5,000.00	25,000*

Table 5: Turkey Graphite Production between 1985-1999¹¹

just because flake graphite prices actually high enough to show the investors a profitable project. We will see some price decreases in the market and they will significantly affect these projects and juniors. Almost all of these projects are financial investment/venture capital projects, and even a small price decrease will create a panic for financial investors. For this reason to develop low cost mining projects are very important.

GRAPHITE IN TURKEY:

In 8th Quinquennially Development Plan it was said that: "Graphite studies and works in Turkey was started in 1941 in Turkey according to MTA (General Directorate of Mining Exploration and Research of Turkey) and Mining Affairs records, and in over 22 region, economi-

cal graphite mineralization determined." Unfortunately we couldn't find too much detailed work on graphite mineralization in Turkey but at least we know where the mineralization is and what could be the quality of it. According to MTA all the determined mineralization is amorphous type, some of the important reserves and grades in Turkey are as follow:

In 1980 Turkey has two graphite miners, producing graphite from their underground graphite mines, These are Karabacak Mining (now Oysu Graphite) whose mines and flotation plant located in Kütahya - Altıntaş - Oysu and Bilginer Mining whose mine located in Muğla-Milas-Yayladerere. Both of the companies carried out some flotation enrichment studies, and in 1991 Karabacak mining set up a 100 mt/day input capacity flotation plant in their mine, and Bilginer mining also set up a small pilot flotation plant in their mine in Muğla. But in 1992 China entered the graphite market with low prices, and market discovered petroleum coke as a subsidiary of graphite mainly in steel industries. These create a collapse in the market and not only in Turkey but also all over the world, lots of mine and producers stop their production.

Till 1999 graphite production continue in Turkey but later stopped again, and in 2008-2009 flotation plant in Kutahya

Year	Production (tonnes)
2003	0.00
2004	28.00
2005	0.00
2006	0.00
2007	0.00
2008	3,236.00
2009	2,400.00

Table 6: Turkey Graphite production between 2003-2009¹³

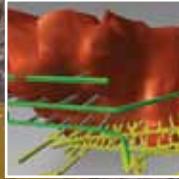
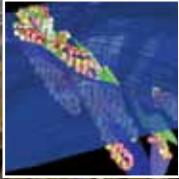
Most important figure in these tables are production of 26,000 mt of graphite in 1991. If Turkey could hit the same production figures again, these means that Turkey could be one of the top five graphite producers in the world. With best of my knowledge and experience, I believe that Turkey could hit this pro-▶



Place/City	Reserve Quantity (metric Tonnes)	Average C %
Yozgat	< 100 000	45
Kastamonu	Unknown	60
Aydin	150 000	10
İzmir - Tire - Karamersin	150 000	8
İzmir - Tire - Çeşme	200 000	6
İzmir - Tire - Başköy	150 000	10
Istanbul	150 000	30
Mersin	Unknown	45
Adiyaman	Unknown	45
Mugla	30 000	10
Kutahya-Oysu	130 000	20

Table 4: Main Graphite Mineralization in Turkey¹¹

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CASE STUDY: A SMALL AMORPHOUS GRAPHITE MINE IN TURKEY

People who read this article could ask several questions; Why invest in Amorphous Graphite in Turkey? And Is it really worth to consider to invest a small reserve? I want to analyze a small graphite deposit, and I think this will answer lots of questions. I couldn't give exact location, and information about the mine as it is a confidential project currently prepared for a company. But It is 230 km far from one of the main ports of Turkey, and very close to infrastructure. I will use one of the SGS reports and figures for cost and capital investment requirement, so that we will have internationally accepted costs. There is 4 geophysics anomalies determined and only 1 of them was tested with drill, and for this one anomaly MTA calculated following figures (data taken from MTA records);

Information About the Mine	
Possible Reserve	307,146 mt
Strip Ratio	6.14 mt/mt
Average Grade	26.45 % Fix C

With this reserve figures we are planning to produce roughly 21,000 mt of concentrate with 85% C content and with 95% efficiency. 21,000 mt won't have too much negative effect on supply side so that we could benefit with current high price level. For production of 21,000 mt concentrate annually, 250 mt/day input capacity flotation plant will be sufficient. And production figures will be as follow;

Yearly ore process and production	
Working days for a month	26
Effective working month/year	11
Working days for a Year	286
Overburden/waste excavation in a year (mt)	438,662.16
Ore excavation in a year (mt)	71,500.00
Concentrate Production in a year (mt)	21,136.66

With above estimation it means that we have 4 years 4 months of mine life. Again according to SGS report, for an investment of a flotation plant it must be considered 20,000 USD / per ton of plant input capacity. So for a plant with 250 mt/

day input capacity we are talking about 5 million USD for flotation plant. We also consider some other investment cost, and some due diligence costs before investment as follow;

Flotation Plant Investment	\$5,000,000.00
License Purchasing Cost	\$100,000.00
Licensing and Permissions	\$70,000.00
Settlement and Startup	\$200,000.00
Drillings	\$160,000.00
Analysis and Test Works	\$30,000.00
Contingency 10%	\$546,000.00
Total Investment	\$6,106,000.00

For mining and processing cost, SGS advises following figures which we believe that reasonable also for Turkey (even it is a bit high);

Production Costs per tonne	
Overburden&Waste	\$3.81
Mining Costs Ore	\$4.11
Processing Cost (incl Administration costs)	\$13.69

With Consideration of above cost we reach following annual cost table;

Annual Cost Calculation	
Overburden&Waste	\$1,671,302.84
Mining Costs Ore	\$293,865.00
Processing Cost	\$978,835.00
Total	\$2,944,002.84

And finally we reach below profit/lost table with 3 different price level.

	Selling Price 1	Selling Price 2	Selling Price 3
	\$500.00	\$600.00	\$800.00
Concentrate Production Per year (mt)	21,136.66	21,136.66	21,136.66
Sales Income	\$10,568,330.88	\$12,681,997.06	\$16,909,329.41
Production Costs	\$2,944,002.84	\$2,944,002.84	\$2,944,002.84
Transportation Costs Per tonne	\$60.00	\$60.00	\$60.00
Annual Transportation Cost	\$1,268,199.71	\$1,268,199.71	\$1,268,199.71
First Year Sales Profit (EBITD)	\$6,356,128.34	\$8,469,794.52	\$12,697,126.87
Sales Profit Over Mine life	\$27,304,382.31	\$36,384,178.43	\$54,543,770.65

As you see above table, in worst case scenario for 500 USD price for 85% Fix C content graphite, project will have 6,3 million USD net profit in the first year which even pay the investment cost in year 1.

CONCLUSION:

Graphite is a critical raw material with in-



creasing importance. Even without considering new demand drivers, traditional markets such as Steel and refractories are very important industries for consumption. Especially because of China, industry faces an important supply gap, mainly traditional graphite consumers. But because of the current market and economic conditions low cost projects are very important, as prices could fluctuate in the short term.

Turkey has a graphite mining history for more than 30 years, and geographically it is very close to Europe which is the main importer of graphite. According to UN trade statistics EU importing roughly around 150,000 mt graphite annually and this demand is mainly met by China. So a very important market is just next to Turkey and when you consider the delivery time and logistic costs, Turkey has very important competitive advantages against China.

Our case study that we explain above shows us that even a very small reserve with high grade ore (when we consider this project with other 26% fix C content, it has the highest quality ore among other projects worldwide) offers very profitable mining business.

And we know that some of the mine, which is not yet studied had over 60% C contented ore in Turkey.

We can't say Turkey is an important player, and have significant graphite reserves, but to have a profitable graphite mining, we don't need million tonnes of ore and to be number one in the world.



Even with some additional R&D for producing higher grade graphite concentrates, we will have better profit scenarios, because higher grades offer higher values. And we can say without doubt that, yes Turkey offers profitable, small scale, manageable, high profit, low cost graphite opportunities. ●

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