Global Securities
CORPORATION

## RESOURCE OVERVIEW

**December 2005**

# Graphite

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## Summary

Graphite is an industrial mineral whose ability to withstand extreme temperatures and corrosive environments makes it suitable for a wide variety of industries. The applications for graphite are increasing as processes are developed to improve the purity of the graphite or to modify it. Graphite is used in the automotive and chemical industries as a gasket material and it is finding its way into the electronics and nuclear industries. In the metals industry, graphite is used in the manufacture of high-temperature bricks and for steel-casting components. It is used for brake linings and in the manufacture of batteries and fuel cells.

The primary source of graphite is China. In 2004, China produced 71% of the world's graphite, followed by India and Brazil. The only operational mine in North America is located in Quebec, although there are other graphite deposits throughout Canada and additional mines are preparing to enter into production.

The price of graphite is negotiated between the producers and the buyers since there is no open market for graphite. The price that is established depends on the type of graphite as well as its carbon content, purity and physical properties such as flake size. The price difference between low-grade amorphous graphite and high-purity flake graphite can be more than an order of magnitude.

Over the past five years, world production of graphite has been increasing. With China and India adding additional steel-making capacity over the next couple of years and the automobile and battery industries increasing production, the demand for graphite should be strong in the short to medium term.

## Types of Graphite

Graphite is a natural form of carbon that is found most commonly in metamorphic rocks such as marble, schist and gneiss. Graphite occurs naturally in three forms:

- amorphous,
- lump, and
- flake.

### Amorphous Graphite

Amorphous graphite is formed from metamorphosed coal and the crystals are very small. This is the least expensive of the three naturally-occurring types of graphite and it has limited applications. It is used for coatings, pencils, brake linings and as a lubricant. In many developing countries, amorphous graphite is used as a carbon additive in metallurgical processes because it is cheap and readily available.

### Lump Graphite

Lump graphite deposits occur in fissures, veins or cavities in igneous or metamorphic rocks. The graphite particles range in size from fine grains to large lumps, and veins can be from 2 mm to 2 m in size. Lump graphite is used as a lubricant, in castings and in batteries.

### Flake Graphite

Flake graphite is generally found in "pockets" in metamorphic rocks as isolated, flat plate-like particles that range in size from fine to coarse. It is used for industrial applications such as refractories. Flake graphite is also used for brake linings, batteries, fuel cells, gaskets and other high technology applications.

## Graphite Production and Processing

Graphite ore is mined using open pit or underground mining methods. Beneficiation of the ore varies from complex flotation circuits to simple hand-sorting of high-grade ore in places such as Sri Lanka. To obtain high purity graphite (>98%), specialized refining processes are needed.

### Sources of Graphite

The following table lists the top seven natural graphite-producing countries and their production output.

| Country | 2004 Production (metric tons) |
|---|---|
| China | 700,000 |
| India | 120,000 |
| Brazil | 61,000 |
| North Korea | 30,000 |
| Canada | 25,000 |
| Zimbabwe | 10,200 |
| Czech Republic | 10,000 |

Source: 2004 USGS Minerals Yearbook

Global production of natural graphite increased to 982,000 tons in 2004, up slightly from 2003. China is the world's leading producer, followed by India, Brazil, North Korea, Canada, Zimbabwe, the Czech Republic, Mexico and the Ukraine. China accounted for 71% of the world's production in 2004. It also holds the world's most significant, known reserves, well ahead of the Czech Republic which is in second place.

## Graphite Production in Canada

Graphite deposits in Canada are of the flake and lump variety and are usually associated with gneiss and crystalline limestone. Most of the deposits have been identified in Quebec and Ontario, but New Brunswick, Nova Scotia, Saskatchewan, Labrador and BC have also reported deposits.

Currently, Timcal Canada Inc. is the only operating graphite mine in North America. The mine and concentrator are located in Quebec and have an annual output of 25,000 metric tons. There is a graphite deposit near Nelson in south-eastern BC, owned by Crystal Graphite Corporation, called the Black Crystal Project. No output from this "project" has been reported by independent sources, but the company's web page states that the project is producing "high purity flake graphite".

Worldwide Graphite Producers Ltd., a privately-held company, planned to conduct a drilling program in 2005 on its mineral claims that are also located in south-east BC near Crystal Graphite's claims. According to Worldwide's web page, their intent is to establish a mining and concentrating operation to produce approximately 20,000 tons of graphite per year. The company forecasts it will start operations in 2006.

In November 2005, Industrial Minerals Inc. (IMI) announced its first sale of 2,000 pounds of coarse flake graphite from its Bissett Creek Mine in Ontario. The ore is processed dry using a proprietary process developed by IMI. The company reports on its web page that it has a resource of 640,000 tons, and this is only for 10% of its lease that it has drilled so far. No details were provided as to the expected level of production.

Other mines in Ontario and Quebec were in production but have been mothballed for a variety of reasons such as low recoveries or low graphite prices.

The three Canadian projects described below are included to provide a point of reference for the size of graphite deposits and operations:

- A graphite deposit in Ontario has an average ore grade of 6% carbon and had a production capacity of 3,000 tons per year. The concentrator was to increase the graphite content to 80-85%. The mine started production in June 1994, but no further information was found regarding its history or the size of the resource, suggesting that the facility has been mothballed. Quinto acquired the property in 2001.
- A deposit in northern Quebec has geological reserves of 8.1 Mt (non NI 43-101 compliant) averaging 16.7% carbon. The project does not appear to have progressed into production. The mine was to have been an open pit with a strip ratio of 1:1 and an annual concentrate production of 23,000 tons.
- A deposit in Labrador has probable reserves (non NI 43-101 compliant) of 10.5 million tons of ore grading 21.9% carbon with a 0.9:1 strip ratio.

## Uses of Graphite

Graphite is composed of carbon atoms arranged in hexagonal groups that form “sheets”. These sheets, which have a weak bond between them, form the graphite crystals. Graphite has unique properties that make it suitable for a variety of applications. It is:

- highly resistive to chemical corrosion,
- highly conductive, electrically and thermally,
- resistant to heat (melting temperature of 3,527 degrees C),
- resistant to thermal shock,
- chemically inert, and
- highly refractory.

Additionally, graphite readily absorbs radio waves and has flame-retardant characteristics. Because of these properties there are numerous applications for graphite, including:

- coatings,
- components for continuous steel casting equipment,
- process technology for corrosive applications including heat exchangers and pumps,
- automotive brake linings,
- infrared defence and stealth bomber technology,
- components in fuel cells,
- components in lithium-ion batteries,
- antistatic plastics,
- conductive plastics and rubbers,
- brushes in electric motors,
- electric arc furnace rods for the steel industry,
- neutron moderator for the nuclear industry, and
- lubricant.

Graphite is used in making magnesia-carbon refractory bricks that are used for steel furnace linings, ladles, nozzles and blast furnaces. These carbon bricks require large graphite flakes (100 mesh) with a purity of 95% to 99% (reference 1). Graphite is also used in manufacturing crucibles for steel-making and for components for the production of non-ferrous and precious metals. Amorphous graphite is used as a mould coating in foundries.

Fine-grained graphite is used in the production of dry-cell batteries. Zinc-carbon batteries require a minimum carbon content of 88%, while alkaline batteries require a very fine grain size and a purity of 98%. Through improved refining processes, the use of natural graphite in battery applications has grown and graphite is finding its way into other, new applications in the electronics industry.

In the US, the brake lining, refractory and steelmaking industries consumed more than 53% of the natural graphite imported into the US in 2004. Flake graphite, used mainly in batteries, lubricants, refractories and other applications, accounted for 49% of the natural graphite used in the US. In the US, the consumption of flake graphite increased by more than 21% from 17,700 tons in 2003 to 21,500 tons in 2004, while natural graphite consumption overall, increased by more than 11% (reference 1).

Because of graphite's layered structure, other atoms or small molecules can be inserted into the graphitic material in a process called intercalation. Intercalation changes the properties of the graphite. For example, lithium ions can be inserted to create anodes for lithium batteries (reference 1). Other elements can be added to the graphite during processing to obtain specific properties.

## Graphite Salt and Graphite Foil

Certain types of flake graphite can be used to produce graphite salt. Graphite salt is created by intercalating the graphite with sulphur or nitrogen compounds such as sulphuric acid. Graphite salt expands like popcorn when subjected to high temperatures. This expansion makes graphite salt an excellent fire retardant.

Graphite salt is also used in the manufacture of graphite foil. Expanded flake graphite is passed through high-pressure rolls to create a thin foil. The foil is then used in the manufacture of gaskets, primarily for the automobile industry. The chemical and nuclear industries also use graphite foil, but they are the smallest users. However, they require the highest purity graphite in their product, therefore pay a higher price for it.

Some of the Canadian deposits are of the flake type that is expandable and therefore suitable for graphite salt and foil production. The producers of these concentrates are able to negotiate higher prices than other types of graphite. The flake quality, and consequently the price, depends on the flake size distribution, fines, carbon and ash content[1]. The outlook is that the application of these products will continue to grow.

Flake graphite used to manufacture graphite foil comes from mines in Canada, China, Madagascar and Zimbabwe. China is the largest producer of high-purity graphite for the manufacture of graphite salt, and in 1994, Japan was the largest producer of graphite salt.

## Substitutes for Graphite

While the application of graphite has been growing in many industries, it is also being replaced in some applications by synthetic graphite, recycled graphite, or other substitutes.

Synthetic graphite is produced from petroleum. In North America, synthetic graphite accounts for a much larger share of the graphite market than natural graphite. According to the US Geological Survey (USGS) report on graphite, the US produced 249,000 tons of synthetic graphite in 2004. Synthetic graphite does not have the coarse crystals of natural graphite, so the applications for this material are limited. It does, however, serve a large specialized market, namely as a carbon raiser additive in iron and steel-making processes.

Synthetic graphite is also used to manufacture alkaline batteries. In the manufacture of low current batteries, carbon black is replacing graphite because of its lower cost. Synthetic graphite and coke may also serve as a substitute for natural graphite in iron foundries, where it is added to iron melted in electrical furnaces to raise the carbon content.

Recycled graphite products are finding a growing market. The graphite in items such as refractory bricks is being recycled to create brake linings and thermal insulation.

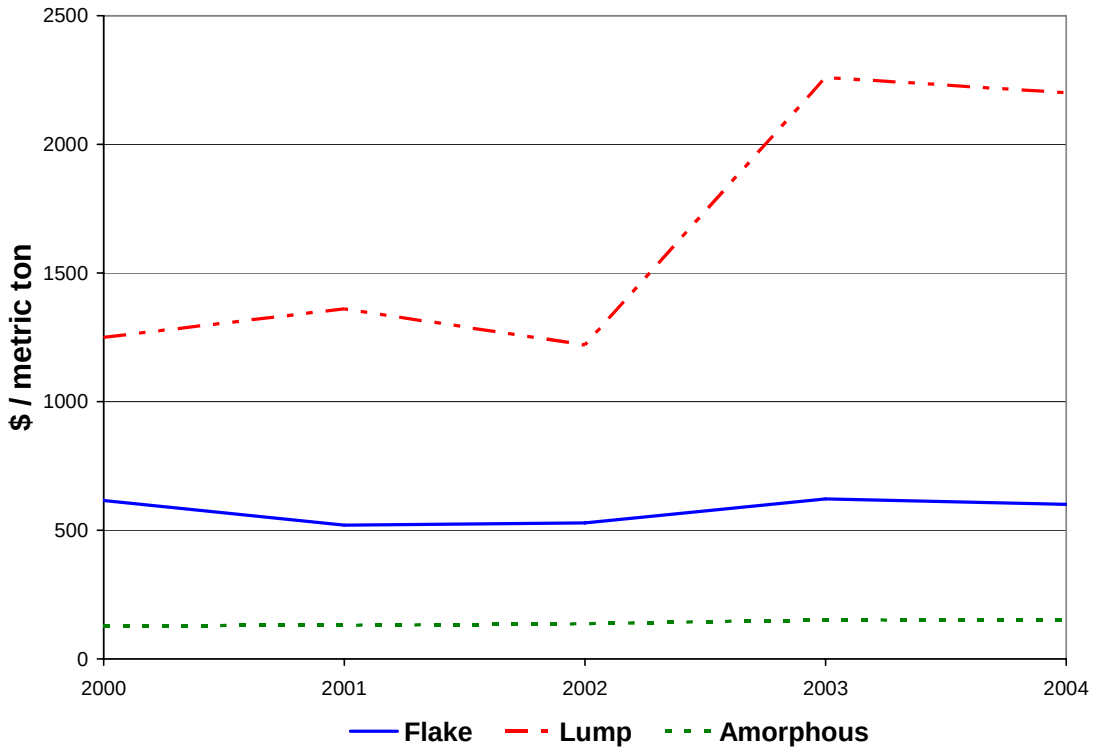
For dry lubrication, molybdenum disulfide has been used as a replacement in some applications. A mixture of finely-ground coke and olivine is a potential replacement for some foundry applications. Kish, which is a residue from steel-making, can be transformed into synthetic flake graphite; however, the technology is still too expensive relative to natural graphite (reference 2).

[1] The 1994 Canadian Minerals Yearbook defines ash as comprising "varying amounts of trace elements plus larger quantities of silica, sulphur, iron, aluminum and magnesium".

## Pricing

The price of graphite depends on the type of graphite that is produced. The figure below shows the average price per ton (at foreign ports) for the three types of graphite based on US statistics. The price for amorphous graphite has risen slightly over the past five years while the price for lump graphite nearly doubled in 2003. One reason for this is that production of lump graphite from Sri Lanka was reduced nearly by half in 2002. The USGS reported that in the US, natural graphite prices remained unchanged in 2004.

For graphite flake, additional factors that determine the price include the purity of the graphite, the amount and type of contaminants, and the size and distribution of the flakes. There is no open market for graphite, so the price is negotiated between the suppliers and their buyers. According to the USGS, in 2004 the price for flake graphite concentrate ranged from US$230 to $750 per metric ton depending on quality. In a news release by Crystal Graphite dated May 16, 2003, they reported receiving approximately US$2,500 per ton for 99% pure graphite. Other sources report that flake graphite has recently sold between US$1,200 and $2,000 per ton depending on the quality.




Source: USGS Mineral Commodity Summary, January 2005

## Outlook

Global demand for graphite is increasing. The automobile industry is a key area of growth, especially in China and other Asian countries that are increasing their automobile production. Since graphite is used in the manufacture of brake linings, graphite will be required not only for new vehicles but also replacement components.

Because graphite is used in batteries and fuel cells, new automobile technologies are also contributing to the growth in demand. With increasing fuel prices and the requirement to reduce engine emissions, automobile manufacturers are starting to introduce more hybrid vehicles onto the market. This trend is expected to increase demand for high-purity graphite for the batteries.

A number of countries including Canada, Germany, Japan and the US are working on developing fuel cell technology, and graphite is one of the key components in fuel cells. Although fuel cells are not yet commercially viable, their market potential is significant and this would impact graphite demand.

Another area of growing demand for graphite is lithium-ion batteries, used in laptop computers and mobile phones. In particular the market for mobile phones, which has recently been growing at around 15% to 18%, is expected to continue to grow for the next several years due to new phone features and emerging markets.

Graphite is a key ingredient in the manufacture of refractory brick, so demand for graphite is tied to the iron and steel industry. China and India are adding additional steel-making capacity over the next couple of years, which should lead to increased demand for graphite in these regions. Graphite is also used in the non-ferrous metal industry for crucibles and other components. The current boom in base metal production (copper, zinc, nickel, etc.) will help maintain a strong demand for graphite.

As processes to purify and modify graphite are developed, the uses and demand for graphite, particularly in the high technology and electronics industries, will continue to grow.

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