Graphite: what every resource investor needs to know

Natural graphite

Natural graphite is a soft, black, naturally occurring metallic mineral, composed of the element carbon (a crystalline, allotropic form of carbon). Graphite is used as a solid lubricant, as a moderator in nuclear reactors... and in pencils. Both the European Union and the United States have named graphite as a critical mineral.

There are three types of natural graphite: amorphous, flake and vein. Amorphous graphite is a naturally occurring seam mineral formed from the geologic metamorphism of anthracite coal. This form of graphite is called amorphous because to the naked eye, macroscopic graphite crystals are not visible and, as a result, has an amorphous appearance. Amorphous graphite contains 70% to 75% carbon and is the most common type of graphite.

Flake graphite is a naturally occurring form of graphite. Its properties include high thermal and electric conductivity, and low spring-back (excellent molding characteristics). Flake graphite is 85% to 90% carbon and its used in many high-value applications including batteries, powder metallurgy, fuel-cell
bipolar plates, coatings, thermal materials, friction moderators, electrically conductive materials, refractories, general lubricant applications, pencils, gaskets, rubber compounds, and other advanced polymer systems.

Vein graphite is a naturally occurring pyrolytic carbon. This form of graphite is deposited as solid graphite directly from a fluid phase, creating an extremely high degree of crystallinity. Vein graphite is utilized extensively in formed graphite products for electrical applications. High-quality electrical motor brushes and other current-carrying carbons are based on formulations using vein graphite. It is also used in friction applications, such as advanced brake and clutch formulations, as well as most applications that utilize flake graphite. Vein graphite is also the type of graphite used in pebble-bed nuclear reactors. Vein graphite is 90% to 96% carbon and is most valuable because it requires the least processing to achieve ultra high purity.

Natural graphite is used mostly in what are called refractory applications. Refractory applications are those that involve extremely high heat and, therefore, demand materials that will not melt or disintegrate under such extreme conditions. One example of this use is in the crucibles used in the steel industry. Such refractory applications account for the majority of the usage of graphite.
Flake graphite powder

It is also used to make brake linings (and other components in the automotive industry), lubricants and molds in foundries. Graphite also has a myriad of other uses in batteries, lubricants, fire retardants, and reinforcements in plastics. Industrial demand for graphite has been growing at about 5% per year for the past decade, due to the ongoing industrialization of China, India and other emerging economies. However, the blue-sky thinking for the graphite industry is the incremental demand that will be created by a number of green initiatives including lithium-ion batteries, fuel cells, solar energy, semi conductors, and nuclear energy. Many of these innovative applications have the potential to consume more graphite than all current uses combined.

The market for graphite exceeds 1 million tonnes per year, of which 60% is amorphous and 40% flake. Only flake graphite, which can be upgraded to 99.9% purity, is suitable for making lithium-ion batteries. The graphite market is almost as large as the nickel market (1.3 million tonnes per year), far larger than the markets for magnesium, molybdenum or tungsten, and more than 50 times the size of the lithium or rare earth markets.

Like uranium, there is a posted price for graphite, which provides a guideline with respect to longer-term trends, but transactions are largely based on direct negotiations between the buyer (or end user) and seller (producer). Graphite prices are also a function of flake size and purity with large flake (+80 mesh, +94% carbon) varieties commanding premium pricing. Prices exceeded USD$1,300 per tonne in the late 1980s, but crashed to USD$600 to $750 per tonne in the 1990s, as Chinese producers flooded the graphite market. During this period there was essentially no global exploration for graphite and, as a result, there are very few projects in the
development pipeline.

Graphite prices did not start to recover until 2005 and easily surpassed previous prices, with premium product selling at close to USD$3,000 per tonne as the supply of large flake, high-carbon graphite was tight in early 2012. Price appreciation was largely a function of the commodity cycle and the industrialization of emerging economies, as new, high-growth applications such as lithium-ion batteries have not yet had a substantial impact on demand and consumption. Graphite prices have since come down by about a third, due to slower growth in China and economic weakness in the US and Europe. No new graphite mines were built during the last cycle and, according to commodity experts and industry analysts, the supply problem will become significantly more acute as economies recover.

It is estimated that the world reserves of graphite exceed 800-million tonnes. China is the most significant graphite-producing nation, providing nearly 50% of the US’s annual graphite demand. Flake graphite is also imported to the US from Brazil, Canada and Madagascar. Lump graphite is imported from Sri Lanka. Graphite resources in the US are very small. For a number of years, the US has not produced natural graphite and is completely dependent on the combination of imported, synthetic graphite and recycled graphite sources.
Graphite lubricants are for use in extremely high or low temperatures.

China produces over 80% of the world’s graphite supply. Approximately 70% of Chinese production is fine or amorphous (mainly low-carbon, low-value powder) graphite while 30% is flake. China produces some large flake graphite, but the majority of its flake graphite production is very small (in the +200 mesh range). China was responsible for the large decline in graphite prices in the 1990s as a substantial amount of product was dumped on the market; however, this is unlikely to be repeated due to the phenomenal growth in the Chinese domestic steel industry (which internally consumes a great deal of graphite). Furthermore, Chinese graphite is declining in quality and costs are increasing due to the effects of high grading and to tightening labor and environmental standards. The majority of Chinese graphite mines are small and many are seasonal. Easily mined surface oxide deposits are being depleted and mining is now moving into deeper and higher-cost deposits. China now has a 20% export duty on graphite, as well as a 17% VAT, and has instituted an export licensing system. The situation is being exacerbated by the modernization and consolidation of the Chinese graphite industry, which is eliminating marginal
producers and may lead to lower production. In other words, China’s declining production, declining exports and increasing costs are creating serious graphite supply concerns for the rest of the world. It is anticipated that demand for high-purity natural graphite will outpace supply in the near future.

Three key factors that determine graphite price are flake size, grade and purity. Flake graphite is a naturally occurring form of graphite that is typically found as discrete flakes ranging in size small, medium and large mesh (large flake size is needed for high-purity graphite). Flake graphite is in highest demand, due to its versatility, but it also in the lowest supply. As a result, flake graphite commands the highest premium, with larger flake sizes having higher prices than a smaller flake size of equal purity.

Graphite facts:

- The term graphite (writing stone) was coined by Abraham Gottlob Werner in 1789
- Most of the large-flake graphite deposits are found at or near surface and are amenable to open-pit mining; therefore, large-flake deposits generally make for low-cost mines
- Graphite is relatively simple to mine
- Graphite is used in pencils, where it is commonly referred to as lead (not to be confused with the metallic element lead)
- There is no substitute for graphite in many technologies (i.e. lithium-ion batteries)
- Graphite is the 15th most abundant mineral in the Earth’s crust
- Because graphite doesn’t trade on an exchange, like copper futures or gold, end consumers must secure graphite feed from a producing mine
- Graphite has three forms: diamonds, coal, and graphite
- Graphite flake size is as important as carbon content;
most high-tech manufacturers would prefer to use high-grade (94-99% graphitic carbon), large-flake (+80 mesh) graphite for their products

- Graphite comes in the form of Carbon (C) and is often denoted as C_g, with the ‘g’ specifying the form of carbon
- Graphite metallurgy is simpler to deal with than rare earths – it’s equally important, but less complex
- Natural graphite is significantly less expensive than synthetic graphite
- Graphite is an excellent conductor of heat and electricity and has the highest natural strength and stiffness of any material known today
- Graphite maintains its strength and stability to temperatures in excess of 3,600°
- Flake graphite is sought for its applications in new technologies, like lithium-ion batteries, fuel cells, solar panels, and vanadium redox batteries
- Graphite is one of the lightest of all reinforcing agents and has high natural lubricity
- Less than 50% of graphite produced is of the flake variety. That fact, coupled with the increased demand for this essential mineral, has seen flake graphite command a much higher price than fine-mesh or amorphous graphite