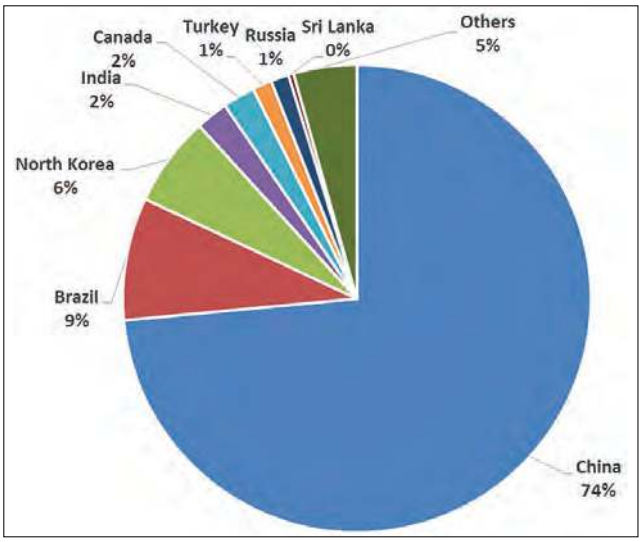
Global graphite market set for change

Graphite has recently been the focus of numerous exploration companies, particularly due to developments in battery technologies related to the emerging electric vehicle and green energy market.

Consequently, the race has been on to report large tonnage exploration targets and mineral resources, with certain projects being described, for example, as "world-class", "biggest" or "highest grade", with perhaps hundreds of millions of tonnes containing a certain percentage of graphite.

Graphite exploration projects may be ranked according to factors such as i) deposit size, contained graphite and enterprise value/tonne of contained graphite (EV/t); ii) location (country risk) and logistics; iii) flake size distribution; iv) product purity; v) off-take agreements; and vi) timeframe to production.

Drivers for success include having a sufficiently high-grade flake graphite deposit with low stripping ratio and, in addition, jurisdiction, logistics, timeframe to production and last but not least, off-take agreements must be taken into consideration.



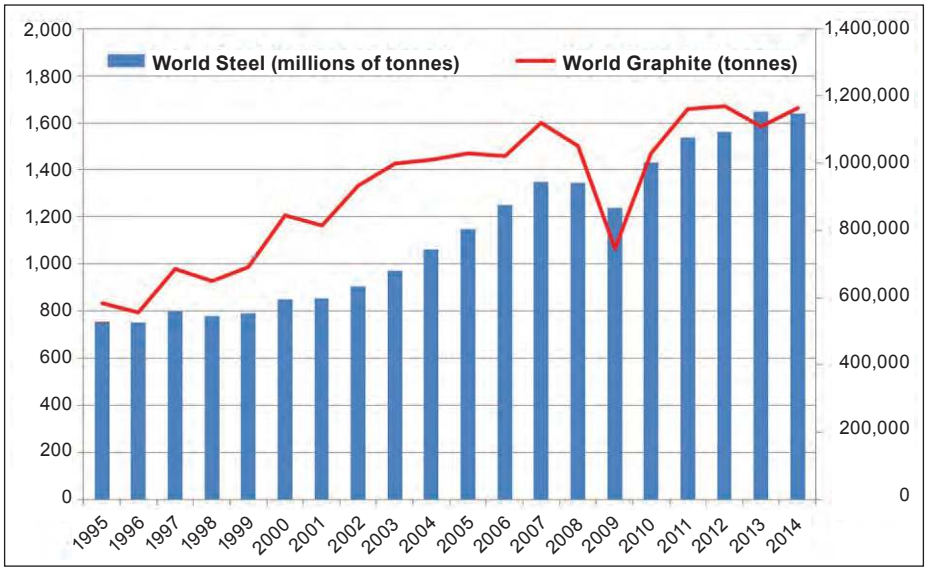
Global natural graphite production (% by country) estimated for 2014. Source: *Industrial Minerals Research*; United States Geological Survey

Global production

Global graphite production has risen more than tenfold, from a base of 100,000 tpa in the early 1900s to an estimated 1.2 mtpa in 2014 at a compound annual growth rate (CAGR) of just over 2%.

While production growth remained relatively slow until the mid-20th century, production increased markedly from about 1950 to achieve an annual CAGR of close to 3% by 2014.

China is the world's leading supplier of natural graphite (flake and amorphous) with approximately 67% of global production according to the USGS, somewhat lower than Industrial Minerals Research's estimated 74%. China's production has grown rapidly since 1998 and overtook the rest of the world in 2000. India, Brazil, Canada and North Korea pr bably account for a further 20-27% of global production. Sri Lanka is a relatively small producer (about 0.5% of global production), although well known for its high quality vein graphite. Brazil is the world's number two producer, contributing about 90,000 tpa of flake graphite. Indian production numbers have been debated for some time; output was 170,000t of flake graphite in 2014 according to the USGS, whereas other estimates put this number closer to 25,000 tpa of flake graphite.



World natural graphite production relative to world steel production. Source: USGS and World Steel Association

Global markets

Natural graphite is a very soft mineral with low density and a metallic lustre and occurs in several forms, described as amorphous, flake and vein. Graphite is flexible and has both metallic and non-metallic properties making it suitable for diverse industrial applications. The non-metallic properties include chemical inertness, high thermal resistance and lubricity, whereas metallic properties include thermal and electrical conductivity. Graphite may also be manufactured synthetically from carbon-bearing raw materials such as petroleum coke and tar pitch.

World natural graphite demand is directly linked to industrial applications, including refractories, automotive, batteries and lubricants. Refractories for the steel industry remain the dominant market for natural graphite consumption and graphite production has tended to follow global steel production, although hi-tech applications such as battery anodes are driving demand for the mineral.

This is potentially one of graphite's fastest growing markets due to interest in electric vehicles, portable electronics and large-scale domestic and commercial energy storage, for example in Tesla's Powerwall batteries. Another fast growing market is predicted to be expandable graphite for foil, insulation and fire retardant products.

The major primary producing and exporting countries are China, North Korea

and Brazil. Importing countries include the US, China (from Korea), Germany, Japan and India which accounted for approximately 250,000 tpa of global trade in 2014. China has consistently been the leading global exporter, while the US has consistently been the leading global importer, sourcing 50,000-70,000 tpa over the past 15 years. Sri Lanka has exported about 4,000 tpa of vein graphite in recent years at prices in excess of $US1,600/t according to UN trade data.

Flake graphite prices remained relatively steady for many years until 2005, after which they climbed gradually to 2008, declined in 2009 following the GFC and then resumed an upward trend, spiking dramatically from 2011 through 2012. Prices have since returned to 2008 levels due to excess production versus market demand.

As a rule of thumb, the larger and purer the graphite flake size, the higher the price. Prices range from about $US500/t (cost, insurance and freight) for minus 75 micron product to approximately $US2,000/t for jumbo flakes greater than 300 micron diameter and greater than 94% carbon content. Uncoated spherical graphite for use in lithium-ion batteries is currently around $US3,000/t, having decreased slightly during 2015. Coated spherical graphite commands significantly higher prices of around $US7,000/t or more.

Graphite consumption per tonne of steel is projected to decrease, as refractory consumption efficiencies improve in China and as global steel production slows. Graphite demand linked to growth in electric vehicles, domestic and commercial power storage could be impacted by alternative battery technology such as aluminium-titanium "yolk-shell" nanoparticle anodes which are likely to use less graphite. If the manufacture of such nanoparticles becomes feasible and economic, the life time of batteries may be significantly extended which would reduce spherical graphite consumption and production.

Risks

Overproduction of flake graphite in China, in addition to proposed production by existing producers in other countries and global graphite explorers, poses a risk to supply-demand balance.

Dr Andrew Scogings is a principal consultant with CSA Global Pty Ltd. He has over 25 years' experience in industrial minerals exploration, mining and processing, product development, market applications and commercialisation processes. Andrew is a regular contributor to *Industrial Minerals Magazine* and has published several papers on the requirements of the JORC Code 2012, with specific reference to Clause 49. He has also written articles ranking global graphite exploration projects and was recently senior author of the *Natural Graphite Report* – strategic outlook to 2020 published by Industrial Minerals Research (UK). Andrew is a Registered Professional Geoscientist (RP Geo. Industrial Minerals) with the Australian Institute of Geoscientists. Andrew will be a keynote speaker at the Australian Graphite Conference