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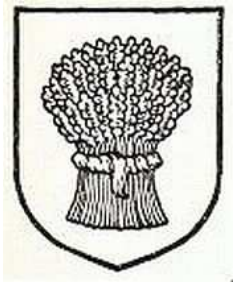

HALLGARTEN & COMPANY

Metals Review

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Tungsten

Now the Tough Get Going

Company	Ticker	Currency	Price	Mkt Cap mn	Stage	Call
Almonty Industries	AII.v	CAD	0.55	83.03	Producer	Long
Blackheath Resources	BHR.v	CAD	0.045	2.22	Ex-producer	Long
Happy Creek Mining	HPY.v	CAD	0.22	20.28	Exploration	Long
King Island Scheelite	KIS.ax	AUD	0.055	11.95	Ex-producer	Long
Ormonde Mining	ORM.L	GBP	0.0235	11.10	Near-producer	Neutral
Northcliff Resources	NCF.to	CAD	0.115	19.71	Exploration	Neutral
Wolf Minerals	WLF.ax	AUD	0.06	59.95	Producer	Neutral
Masan Resources	MSR	VND	28,600	20.58	Producer	Long

Tungsten

Developers Regain Traction

- + The grim years in the Tungsten space mean that the ranks of explorers/developers were brutally thinned out few survivors in the space
- + Tungsten is most commonly used in so called "hard steels" and a vital component in machine tools and drill bits
- + Tungsten prices firmed up nicely in the second half of 2017 and into the current year with no auguries of possible downturn
- × Most of the wannabes of earlier this decade have abandoned their efforts or fallen to consolidators like Almonty
- × Prices have not resurged to levels that make projects with hefty capex requirements much more marketable than in the worst of the slump
- × Raising money for Tungsten projects is still no easy task with many other projects in similarly ignored metals competing for investors' attention
- × The Chinese as both the largest producer and one of the main users have a vested interest in higher prices but that does not mean that they may not push prices down to achieve other policy or strategic goals

Tungsten Redux

Tungsten has long been a metal of interest for the cognoscenti but remains largely unknown to the broader public (investing or otherwise). If they have heard of it, then most likely it would be in the context of some power tool's marketing campaign. However, the metal is indispensable to a lot of applications that are not up close and personal with consumers but vital for the broader economy. To name but a few there are machine tools and all sorts of drilling for both the oil & gas industries and mining. If the recent price surge escaped the attention of the investment community then at least the recent, much-talked about British Geological Survey Risk List has shone a spotlight on the metal ranking it as number four in terms of criticality of supply, ahead of Rare Earths.

The slumping price of the metal has wreaked destruction upon the Tungsten exploration names AND the producers (with both Malaga and North American Tungsten succumbing to Administration). The explorers largely faded into mere shadows or repurposed their vehicles as something else. Meanwhile consolidators like Almonty Industries (one of our long favoured stocks) picked up failing producers as part of its global roll-up strategy and determined explorers made the sacrifices necessary to remain in the land of the living.

In this note we shall look at the implications for the Tungsten sub-space now that the metal's price

shows a strong turn for the better.

At the Sharp Edge

Tungsten takes its name from the Swedish words, *tung sten*, or heavy stone. Its symbol in the periodic table though is W which derives from the name of its discoverer, Peter Woulfe, who in 1779 investigated the mineral now known as wolframite and concluded it must contain a new substance. Scheele, in 1781, found that a new acid could be made from tungsten (a name first applied about 1758 to a mineral now known as scheelite). Scheele and Berman suggested the possibility of obtaining a new metal by reducing this acid. The de Elhuyar brothers found acid in wolframite in 1783 that was identical to the acid of tungsten (tungstic acid) of Scheele, and in that year they succeeded in obtaining the element by reduction of this acid with charcoal. Tungsten occurs in wolframite, scheelite, huebnerite, and ferberite.

Applications

Because it retains its strength at high temperatures and has a high melting point, tungsten is used in many high-temperature applications, such as light bulb, cathode-ray tube, and vacuum tube filaments, heating elements, and rocket engine nozzles. Due to its conductive properties, as well as its relative chemical inertia, tungsten is also used in electrodes.

Its high melting point also makes tungsten suitable for aerospace and high-temperature uses such as electrical, heating, and welding applications, notably in the gas tungsten arc welding process (also called tungsten inert gas -TIG- welding).

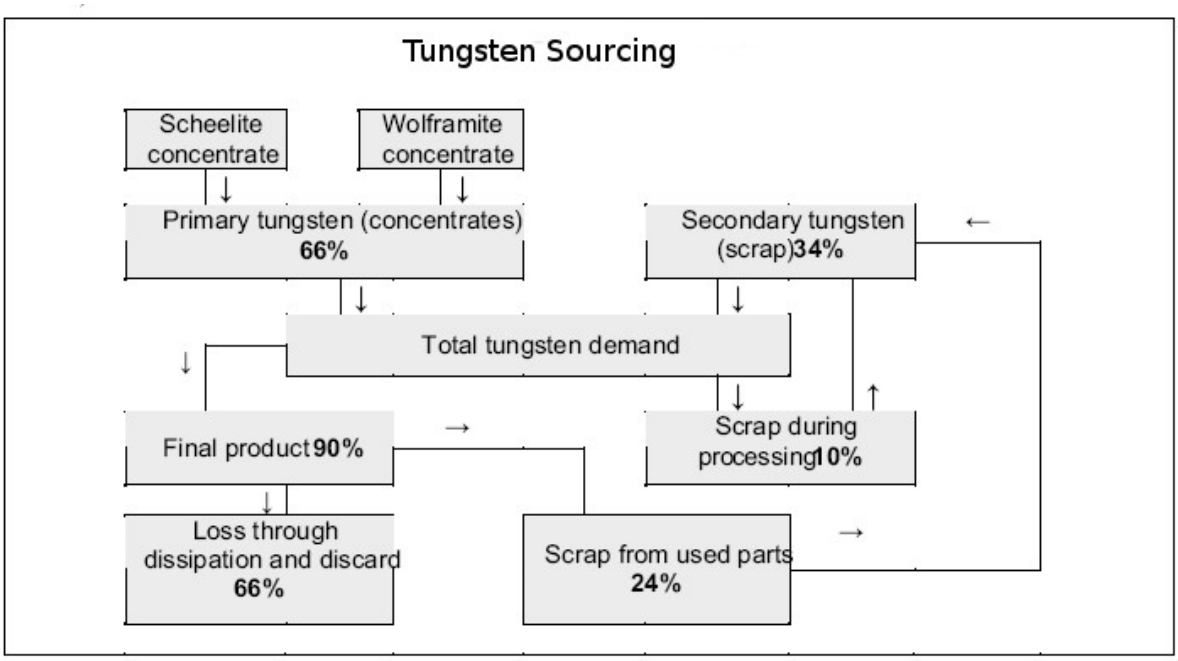
The hardness and density of tungsten are applied in obtaining heavy metal alloys. High-speed steel, may contain as much as 18% tungsten. Superalloys containing tungsten are used in turbine blades and wear-resistant parts and coatings. In its defense applications, tungsten, usually alloyed with nickel and iron or cobalt to form heavy alloys, is used in kinetic energy penetrators as an alternative to depleted uranium but may also be used in cannon shells, grenades and missiles to create supersonic shrapnel.

Tungsten compounds are used in catalysts, inorganic pigments, and as high-temperature lubricants. Tungsten carbide (WC) is used to make wear-resistant abrasives and cutters and knives for drills, circular saws, milling and turning tools used by the metalworking, woodworking, mining, petroleum and construction industries and accounts for about 60% of current tungsten consumption. Tungsten oxides are used in ceramic glazes and calcium/magnesium tungstates are used widely in fluorescent lighting, while tungsten halogen bulbs are frequently used to light indoor photo shoots, and special negative films exist to take advantage of tungsten's unique disentangling properties. Crystal tungstates are used as scintillation detectors in nuclear physics and nuclear medicine. Other salts that contain tungsten are used in the chemical and tanning industries.

Most tungsten concentrates are processed chemically to ammonium paratungstate (APT). Secondary raw materials like (oxidized) scrap and residues are another important feed for chemical tungsten processing. However, wolframite concentrates can also be smelted directly with charcoal or coke in an electric arc furnace to produce ferrotungsten (FeW) that is used as alloying material in steel production. Pure scheelite concentrate may also be added directly to molten steel.

Supply

The flowchart below shows how the Tungsten users acquire their metal. This chart, originally from the ITIA, was part of a presentation by Wolf Minerals to a UK parliamentary committee. As can be noted, in this version, it is claimed that 34% of supply comes from recycled metal.



Source: ITIA

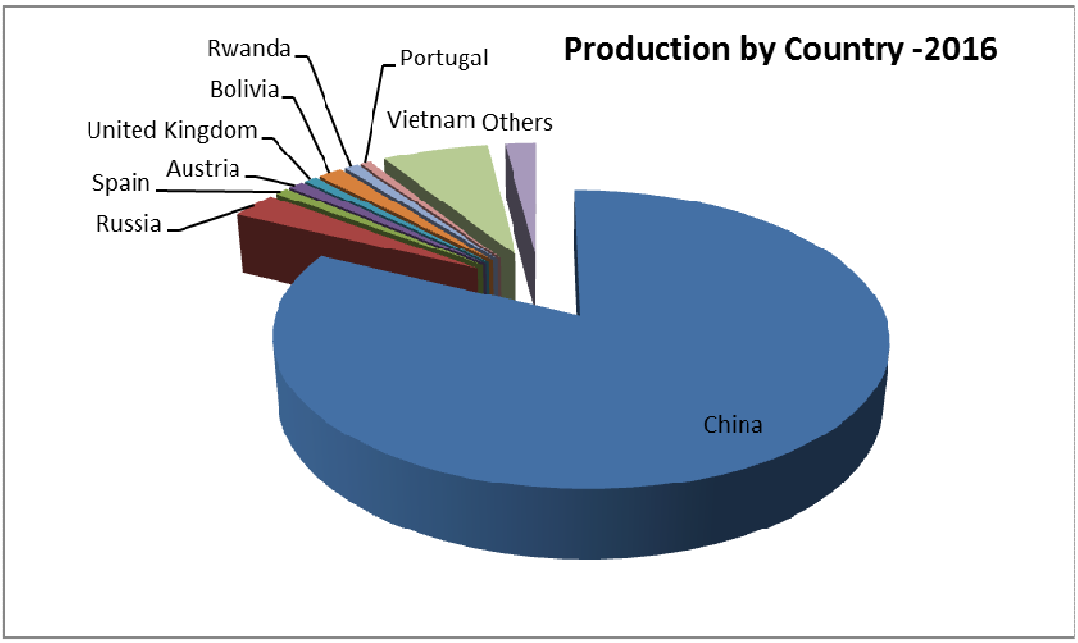
Over the last few decades, sources of primary supply have shifted totally. In 1986, the USSR was the world's largest consumer but, by 1992, the reformed CIS was exporting Tungsten and by 1996 was the world's second largest supplier. In the late 1990s and at the beginning of the new millennium, China had risen to dominate production with 90% of the world market for Tungsten production and supply. This was despite China supposedly having about 75% of the world's Tungsten resources.

This shifting dynamic makes it hard to identify where exactly the future production will be coming from. The calculation of global reserves leaves something to be desired in our view. On the Chinese side we, as in so many other things, have no verification of how large reserves are or the pace at which they are being consumed (something that has been an issue also in Rare Earths and Antimony in recent times).

On the Western side there are known reserves of Tungsten that are the result of decades of low focus on exploration. The fact that several relative newcomers to the space in the 2008-12 period came up with substantial new resources rather swiftly after beginning exploration might imply that the West's share of global Tungsten resources is severely underestimated (as it has been in Antimony and Rare Earths).

Who Has It

The latest assessment of the USGS (from 2016) is that China has 61% of global Tungsten resources, Canada with 9% and Vietnam with has 3%. However, it is not which country currently has the resources that matters but the country that gets into production first. Thus Portugal currently has more going on in the Tungsten space than Canada does, while South Korea currently has no production but when Almonty get their Ssandong operation going there the country might account for 7% of global production and fully 50% of ex-China output. Curiously Korea does not figure in the ranking of major resource holders (despite its putative mine once being the world's largest).



Source: USGS

This moving feast means that, besides China and Russia, other principal producing countries are Austria, Bolivia, Portugal, Spain, the UK, Rwanda and Vietnam whilst mines have closed in the last decade in Australia, Brazil, Canada, France, Japan, Peru, South Korea, Sweden, Thailand and the USA. Chinese production hit a new high of 2011 at around 70,000 tpa and then declined by around 10% according to Roskill. However by 2016 this crept back up to 71,000 tpa, largely by knocking countries such as Canada Peru and Australia out of the running

Vietnam's production doubled from 3,000 tpa in 2013 to 6,000 tpa in 2016. The Australian presence has reappeared again in a small way since 2016 with Almonty's Wolfram Camp mine there.

Not only have the sources of supply altered but so have the Tungsten compounds traded, as fluctuating price differentials between concentrate and upgraded products and governmental restrictions played their part in the market. In just the period 1986 to 1996 the concentrate trade plunged from 84% to 29% while intermediate products (including tungstates, tungsten oxides and hydroxides, W and WC powders, and ferrotungsten) soared from 16% to 71%, largely reflecting the shift to China dominance with the Chinese wanting to hold onto the value added. The concentrate trade might start to trend up again as

China dominance retreats.

Recycling

Several years ago, the consultants Roskill in their review of Tungsten trends up until 2018 noted that secondary production of Tungsten (i.e. recycling) had become an important factor in the Tungsten supply equation. They noted that processors such as Plansee, H.C. Starck and Kennametal had expanded their recycling efforts. It noted that Europe and the US had become the main locations for recycling with around 45% of demand met by recycled material in 2013, while in Asia, Japan sourced only around 20-30% of its required material from recycled sources in the same year. Arguably the low prices in the interim will have held back the urge to recycle as primary metal was so inexpensive.

Sources of Production over the last 10 Years	
Primary	55-60,000 tpa
Recycling	20-25,000 tpa

Tungsten scrap, due to its high tungsten content in comparison to ore, is a very valuable raw material. The recycling process also enables the recovery of other critical and strategic metals such as cobalt, tantalum and niobium. Increasing recycling would reduce to a degree the need for new primary extraction of tungsten. However, the growth in demand means that even a very large rate of recycling could not satisfy demand. There are limits also to the amount that can be recycling because as Tungsten is used in wearing environments the tools/bits it hardens lose their Tungsten edges and coatings through attrition leaving less to potentially recycle.

The China Factor

We see in Tungsten the same dynamic that other specialty metals (e.g. Rare Earths, Antimony) have experienced over recent decades. During the 1980s and the 1990s, China, with the world's largest reserves and lowest cost of production, flooded the world market. This drove down the price of both APT and WO_3 concentrates to below the production cost of most other producers. Amongst the distortions this produced was that APT prices, driven downwards by Chinese processors, were only marginally above the price of concentrates at about USD$50 per MTU (metric ton unit = 10kg).

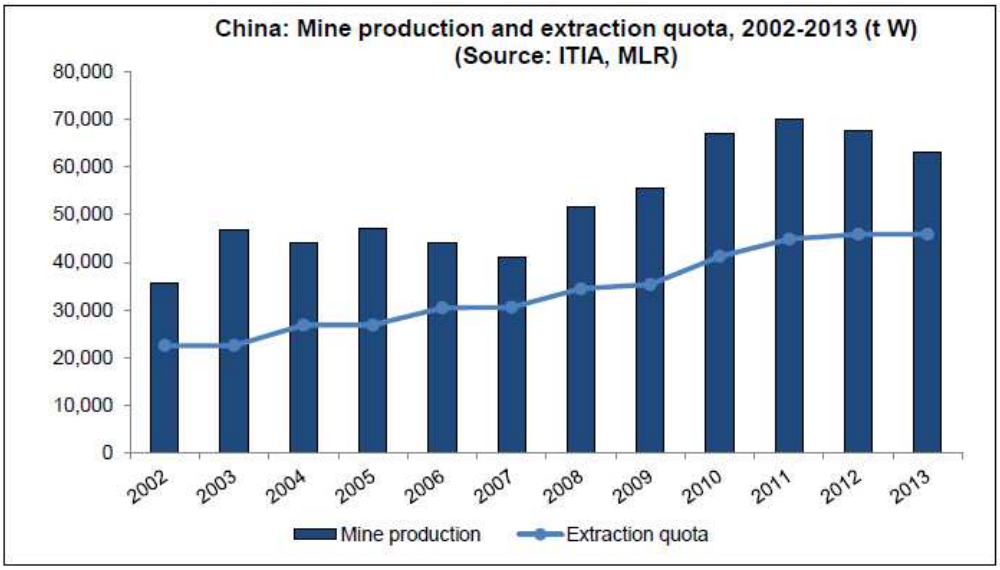
The distressed price in the world market quickly drove many tungsten mines and APT producers in the Americas, Asia and Europe out of business and led to their closure. Moreover, outside of China, exploration and mine development programs were quickly abandoned.

However, the distressed market price for tungsten concentrates and its products began to change in 2003 and more markedly in 2004-2005 propelled by the rapid growth and emergence of the Chinese economy in the world marketplace. As in other metals the rapid growth of Chinese demand for Tungsten products for its domestic market triggered a tightening of the availability outside of China which was coupled with the Chinese government's policy curtailing mining projects and taxing the export of Tungsten concentrates in order to conserve resources for future domestic needs. This led to a

price surge in 2005 with the price of APT moving rapidly from below $80 to nearly $300 per metric tonne unit (MTU). This in turn sparked a recovery in Tungsten recycling, so the price stayed in the $250 range for the ensuing five years. However, with recycling at its max (37% of global supply in 2010 according to the USGS) and demand for Tungsten still high, the APT price took a strong step eventually peaking around $460 per MTU.

Disciplining the Market

Just as in Rare Earths and other specialty metals the Chinese government is curtailing mining programs and strongly "encouraging" downstream processing of concentrates to higher value added products such semi-finished and finished tungsten products. We might also note that before the 2008 slump China had become a net importer of tungsten concentrates and scrap.



Source: Roskill

The chart above shows that China's production peaked in 2011 and then tailed off but have since picked up again. The extraction quotas that the Chinese imposed were regularly blown out by the producers (legal and illegal) but it was interesting to note how the gap narrowed.

This narrowing was probably due to a measure, taken in early 2011, when China's Ministry of Land and Resources announced that authorities in the country had identified and ordered the clean-up of more than 280 illegal mines in an effort to regulate the exploration of valuable minerals. The number of exploration licenses for minerals such as Rare Earths, Tungsten, Tin, and Antimony were reduced to 116 from 400 in eleven provinces and regions in the country via spot checks led by teams dispatched by the ministry. This campaign has aimed to end the supposedly illegal excavation of valuable minerals. These measures, ostensibly, were in an effort to conserve resources.

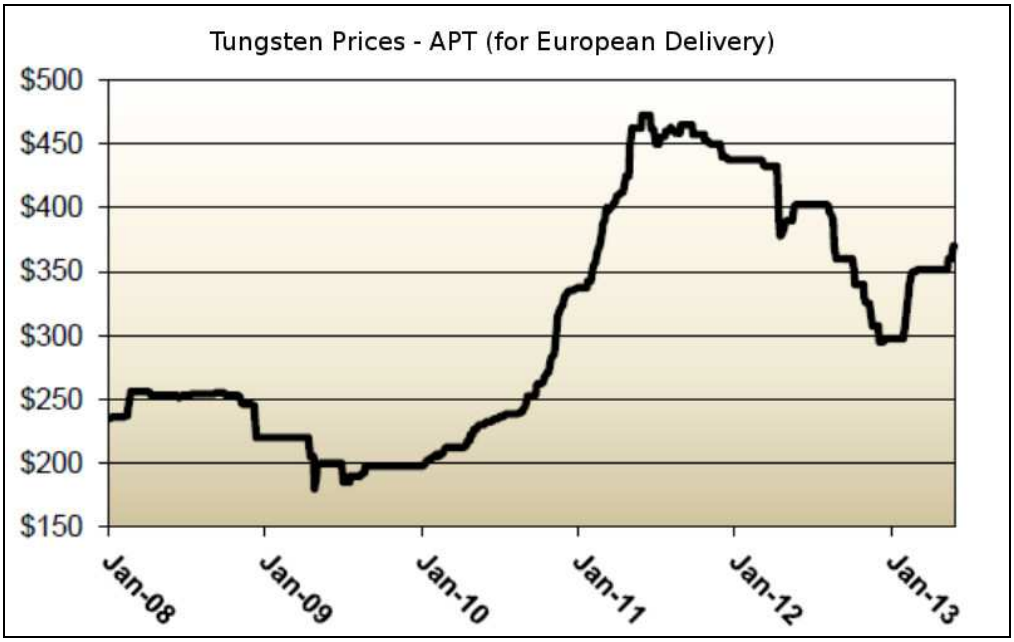
Pricing

The average annual price of tungsten since 1950 fluctuated between a nadir of US$10 per metric ton

unit in 1963 and a peak of US$175 in 1977. After that point it sagged back to trade in a $50-75 band for several decades before its revival in the new century.

As noted earlier, the trade in concentrates diminished and the market relied more and more upon the APT quotation as a price guide since APT is the product traded in the largest quantity. Prices are mainly based on the quotations published twice a week by London's "Metal Bulletin", although other trade journals also publish quotations or indicative prices.

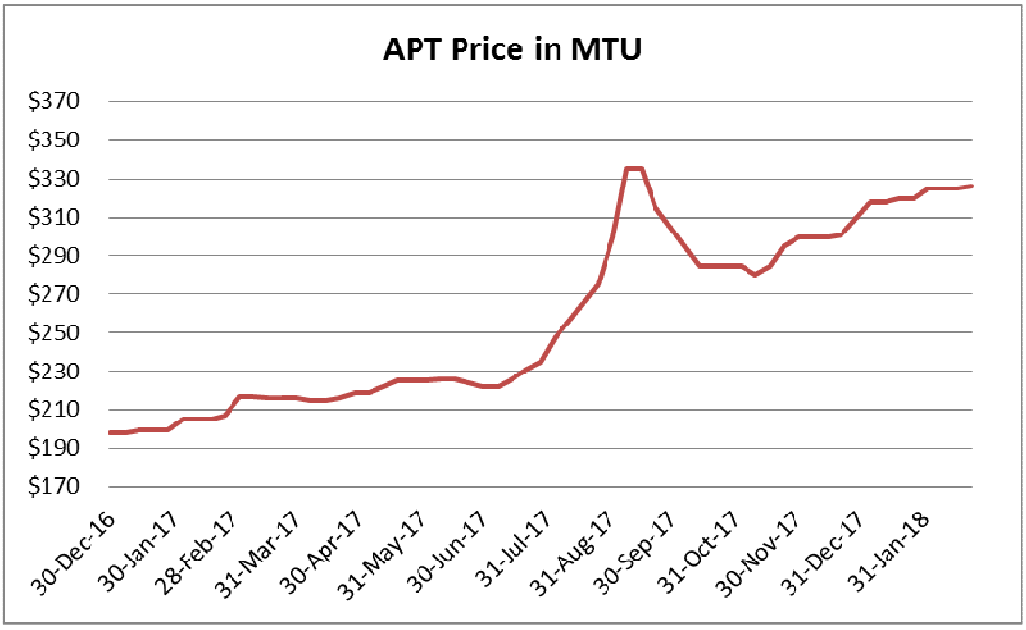
The chart below shows the price trends for APT during its "boom" period post-2009.



This produced a flurry of activity with companies outside of China realizing that they urgently needed to find and secure long-term supply of tungsten and its products from sources outside China. This led to increased investment in exploration and mine development activities outside of China, particularly in Vietnam, Australia and the Americas. Three former tungsten mines were reopened: CanTung (owned by North American Tungsten) in Canada in 2005, the aforementioned Panasqueira (which was acquired by Sojitz) in Portugal in 2005 and Pasto Bueno (owned by Malaga Mining) in Peru in 2006.

Tellingly, since that time, North American Tungsten and Malaga went bust and Sojitz sold its Portuguese operation to Almonty Industries (which was run by the management group that had sold the mine to Sojitz previously).

As can be seen in this more recent chart on the following page, prices have risen 50% over the last year, after having spent the previous three years doodling about just below $200 per MTU of APT.



Source: Almonty Industries

Our latest projections are shown in the table below.

Tungsten APT Pricing Projections	MTU (US$)
2016	$198
2017	$301
2018e	$345
2019e	$395
2020e	$415

This Time it Will Be Different?

Factors militating against a ramp up in production included:

- long lead times between exploration and new mine openings
- the steep rise in mine development and operating costs
- the very limited availability of high grade deposits (i.e. greater than 0.6% WO_3)

The result is that the pipeline of new projects is largely empty and even if potential mines were identified there would be little new significant supply expected over the next 3-4 years. Moreover further price advances for tungsten concentrates and products would be necessary before any new major mining programs could stand a chance of gaining funding. As we have seen APT prices went off a

cliff with the global slump of 2012 and any miners with aspirations to get into production ended up shelving plans for the duration of the slump. This only served to accentuate the China-dependency of the industrial users of Tungsten.

Offtakers Rule!

In sharp contrast to the many other specialty metals, the end users in the Tungsten space are acutely aware of their vulnerability in the supply chain. Not unsurprisingly the major users have moved to try and secure their upstream (as per our mantra in specialty metals "Secure Thy Upstream"). In one case, Sandvik, the major toolmaker, acquired, back in 2009, Wolfram Bergbau- und Hütten-GmbH Nfg. KG, an Austrian producer and supplier of tungsten products which operates a refining plant for producing tungsten carbide, including a chemical plant for recycling tungsten material, in St. Martin, Austria. It also operated a mine and ore dressing plant in Mittersill, Austria. WBH is active within the tungsten industry since 1975 and offers tungsten carbide and tungsten metal powders. Sandvik had been part of WBH's global customer base since many years. Tungsten carbide is the primary raw material of cemented carbide, and therefore the acquisition of WBH is of long-term strategic importance for Sandvik. WBH also has taken a significant stake (alongside Resource Capital Funds) in Wolf Minerals (owner of the Hemmerdon project in the UK).

Almonty's survival and expansion has been encouraged by European machine tool makers prepared to pay over the "market" price for APT to ensure that Almonty survived and prospered as an alternative to the inevitable Chinese near-monopoly if it had gone under.

Western machine tool makers are particularly vulnerable to supply disruptions as it is up against China, making a major push into the tool space and thus we might tactfully say that it would be to the benefit of Chinese toolmakers to have foreign competitors experience supply problems from the Chinese tungsten mines. If any investors doubt that that might happen then they would be naive indeed.

The Tungsten Lifecycle Chart

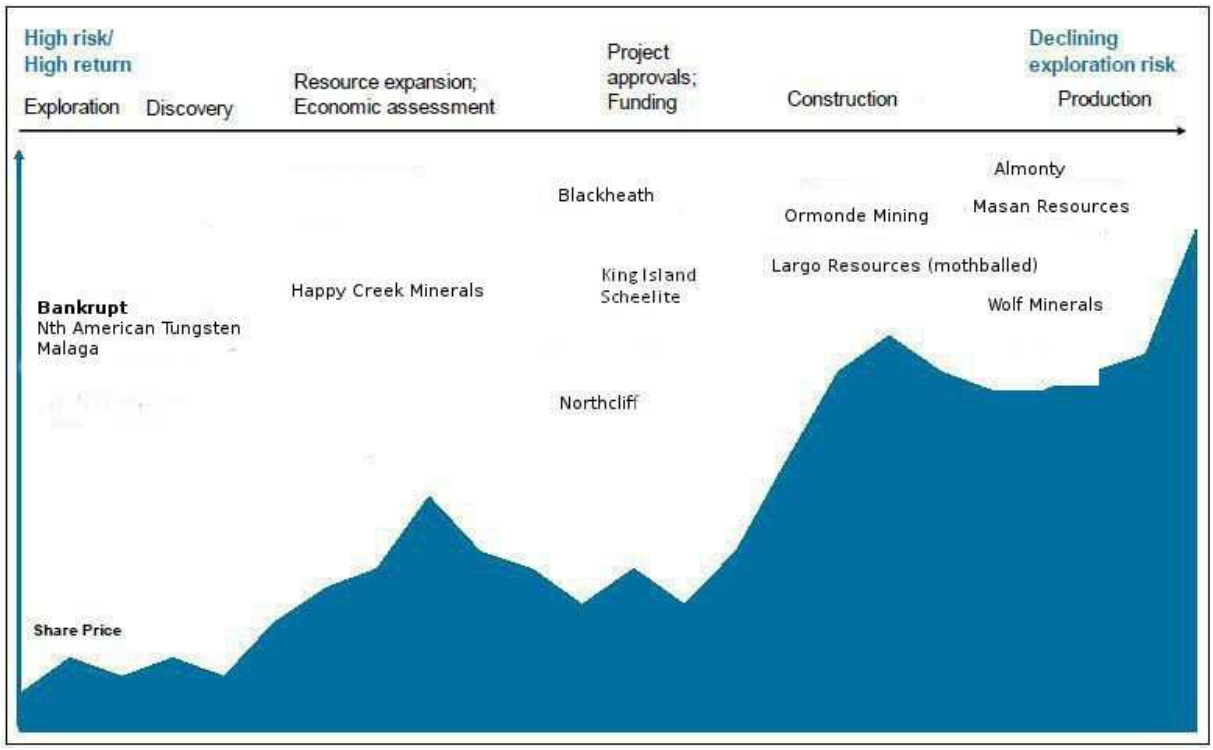
Our all-purpose Lifecycle chart, on the following page, serves particularly well, in the case of Tungsten, to show the state of progress of the various players vis-à-vis each other on the exploration-production continuum.

Unlike past charts where some of the players were not serious about getting to production the culling of the ranks has left only the most devoted Tungsten players.

This chart looks very different from the last time we published it. The activities of **Almonty** in rolling up projects have resulted in it dominating the production end of the chart and it has cleared out a number of long-standing names (e.g. **Woulfe Mining** and Sojitz). North American Tungsten has gone bust. Its big capex Mactung project in the Yukon was, bizarrely, acquired by the government of the Northwest Territories in late 2015. **Wolf Minerals (WLF.ax, WLFE.L)** is in production but a subject of constant speculation.

Carbine abandoned its small scale mine and went in search of gold instead. King Island Scheelite treads water and Colt Resources seems to have gone under. **Malaga** went bankrupt as did North American

Tungsten. Largo entered production then went into hibernation.



The prime challenger to Chinese dominance in the Tungsten space is actually in Vietnam. **Masan Resources Corporation**, listed on Hanoi's UPCoM exchange (UPCoM:MSR), is the largest producer of primary and mid-stream tungsten products outside of China. Its Nui Phao open-pit polymetallic mine, is located approximately 85 km north-east of Hanoi in Thai Nguyen Province. The company acquired it in 2010 as a greenfield project and it was commissioned in 2013, showing that a short time frame to production is possible in this metal. Along with tungsten, the Nui Phao project is also said to contain economic deposits of fluorspar, bismuth and copper.

The process plant at Nui Phao is designed to treat 3,500,000 tons of ore to produce tungsten, copper, bismuth and fluorite concentrates.

Wolf Minerals may have renamed its Hemerdon mine as Drakelands but it is harder to get away from persistent problems than just changing the sign at the front gate of the mine. The £140 million project was officially opened in September 2015, becoming the first new British metal mine in 45 years and one of only two mines outside of China with production capacity greater than 3,000 tpa of tungsten in concentrate. However the opening coincided with the price slump in the metal and the mine then spent several years being put through the financial wringer. Resource Capital came to the rescue but the price has been dilution for shareholders and a creeping takeover by RCF. The upturn in prices was welcome (as well as the retreat in the GBP since the Brexit vote). These two factors may just save Wolf's bacon.

The other producer in the universe is our favoured Tungsten play, **Almonty Industries**, the consolidator in the space. We have written about it elsewhere but essentially it has pooled together producers in Spain, Portugal and Australia and has projects being developed in South Korea and Spain.

Ormonde Mining (ORM.L) is the developer of the Barruecopardo Tungsten Project in northwest Spain, in which it holds a 30% interest. The reduction in its position was due to through a US$99.7 million funding package agreed with Oaktree Capital Management (70% interest) in 2015.

The company claims that its initial nine-year open pit mine is fully funded as a result of the project financing in 2015, which was comprised of US$44.2mn in equity and US$55.5mn in debt, with mine commissioning targeted by end Q4 2018.

Northcliff Resources (NCF.to) continues to put its ducks in order at the Sisson project in New Brunswick but without starting construction.

The various Portuguese properties of **Blackheath Resources (BHR.v)**'s look promising, particularly Covas, but nothing is happening on a mine build yet at what are primarily past-producers.

King Island Scheelite (KIS.ax) is a stock we have covered in standalone notes in the past. Its mine reboot called the Dolphin project has been in somewhat of a holding pattern while prices were low and has gone through various iterations of design to deal with its proximity to the sea.

In the explorer category we know of only one company of note and that is the cheerfully named, **Happy Creek Minerals (HPY.v)** which has a very high-grade prospect on its hands with its Fox project which in in British Columbia. It published an updated resource as recently as January of this year.

Hazelwood Resources changed its name to **ATC Alloys (ATA.ax)** and is a strange beast. It escaped an offer from Almonty only to end up being massively diluted by its partner in its Ferrotungsten refinery in Vietnam. It cannot really be regarded as a miner.

Risks

The risks for the Tungsten space in general. These are:

- A return to a weakening Tungsten price
- Failure of the Tungsten story to reignite when mining market returns to general interest
- Weakened global industrial demand (particularly in tools) that would soften prices and volumes
- China skewing the market in some way to again create distortions in prices and trade patterns

Most of these risks are different sides of the same price prism, with the exception of the market's perception/ disinterest in Tungsten.

Financing remains difficult and dilutive when it takes place. The only way to harvest the more attractive price is to be in production and the only way to do that is to finance mine-builds/reactivations.

Conclusion

Tungsten is one of those metals where the fluctuating price makes it hard to plan a company's trajectory for more than a couple of years. The wild ride in pricing since 2008 made it particularly difficult to chart these waters. Now the trend is turning positive again with a firming price meeting a marketplace that has been deprived of new projects and seen most of the explorers vaporize. Even though the recovery is now in place Tungsten is a metal that has failed to capture the market's interest due to generalized ignorance of Tungsten and its supply/demand dynamics.

Tungsten, in theory, should be a bellwether of industrial activity, more than virtually any other metal, as it is directly levered into machine-tool manufacturing as the swing factor in its demand (the relatively non-variable part being lighting uses). However, the "spoiler" here is China which distorts the Tungsten market much as it has distorted so many others. Now we have a situation where industrial demand is recovering making it harder for China to maintain low prices (to maintain its dominance). Moreover China's attempts to overrun the machine tool sector through its Tungsten dominance have put Western manufacturers of this equipment on notice that they need guaranteed non-Chinese supplies to evade predatory Chinese manouevres.

For the first time since 2010 there now exists a window of opportunity for Tungsten developers to catch the attention of investors, as end users scramble to secure alternative, more reliable sources of supply. The broader economic recovery should lead to increased competition for Tungsten concentrates in the global market between Chinese and non-Chinese processors and consequently result in an improving price structure for Tungsten and its products in the future. A jump in prices of APT to over $400 would not be unthinkable.

Important disclosures

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