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HALLGARTEN + COMPANY

Sector Strategy

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Antimony:
The Stealth Performer

April 2021

Antimony

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- + **The pandemic coincided with a massive rally in two of our favorite metals after years in the doldrums with Tin and Antimony taking off**
- + **Antimony had been in the dumpster since 2014 when the price suddenly soared to around US$17K per tonne**
- + **The rising new applications are molten salt batteries for stationary storage and Sodium antimonate as a coating on PV glass on solar panels**
- + **Decades of over-exploitation by China of a finite resource has resulted in it being forced to pursue artisanal sources around the world**
- ✘ **China has long been the major producer and has called the shots on pricing but is now losing control**
- ✘ **The spike and dump of 2014, followed by a long period of prices below $6,000 per tonne, killed off any putative producers outside China and depressed interest**

Tale of a (Supply) Crisis Foretold

Amongst specialty metals Antimony (Sb) is one of the least talked about, mainly because it has long been dominated by Chinese production (up to as much as 93% of world mined output) and because there are so few listed plays in the metal in Western equities markets.

In recent years, though, the sneaking suspicion has developed that a REE-style crisis in brewing in the less-than-scintillating Antimony space. This crisis has crept up largely in the same manner as the REE crisis did, but in this case the "metal" previously had none of the high-tech glamour of REE and thus has largely slid under the radar of politicians looking for a quick soundbite.

Recent statistics suggest that Chinese mine production has fallen to as little as 53% of global output, but that the country still controls more than 85% of processed production largely by buying product from outside its borders. This situation is only going to worsen as China's mega-mine, long the source of its dominance, continues its terminal decline.

What is It?

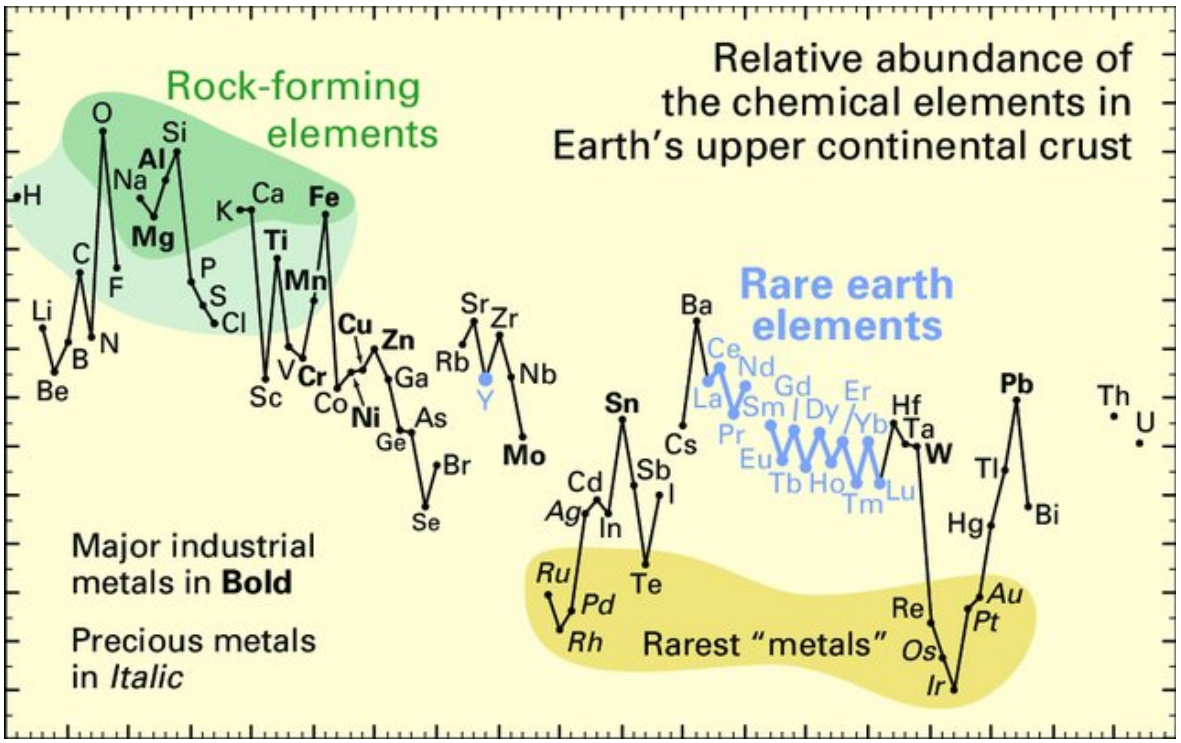
The name Antimony is derived from the Greek words *anti* & *monos* meaning 'never found alone'. The principal use is as an oxide synergist in the flame-retardant chemical additive sector.

China has dominated world supply for the past 120 years.

Antimony (Sb) is a silvery-white, shining, soft and brittle metal. It is a semiconductor and has thermal conductivity lower than most metals. Due to its poor mechanical properties, pure Antimony is only used in very small quantities; larger amounts are used for alloys and in Antimony compounds. Antimony's abundance in the earth's crust is 0.2 ppm, making the element about as scarce as some of the heavier Rare Earth Elements (REEs) and a little above silver (Ag).

Going Critical

The first sign that something was up was when Antimony was ranked first in a Criticality Risk List published by the British Geological Survey in the second half of 2011. The list provided an indication of the relative risk to the supply of chemical elements or element groups required to maintain the current British economy and lifestyle. The list rapidly became the gold standard of critical metals rankings largely because the US and its functionaries dared not speak publicly of the way in which they were so massively wrong-footed in just about every critical metal out there.



Since then the EU, Japan and the US have all added Antimony to their criticality rankings.

Proving Up a Deposit

One of the problems (though to us it is an advantage) of the Antimony space is that proving up a reserve is such a hard thing. To delve into unprofessional jargon we might say that Antimony veins are like long straggly occurrences that stretch over long distances. With the veins ranging from 0.1 metre to maybe

two metres in width it is very easy to drill for Antimony and miss the vein. If the ore is at surface then it's very easy to trench and rockchip sample. Grades can be fantastic at 25% or more.

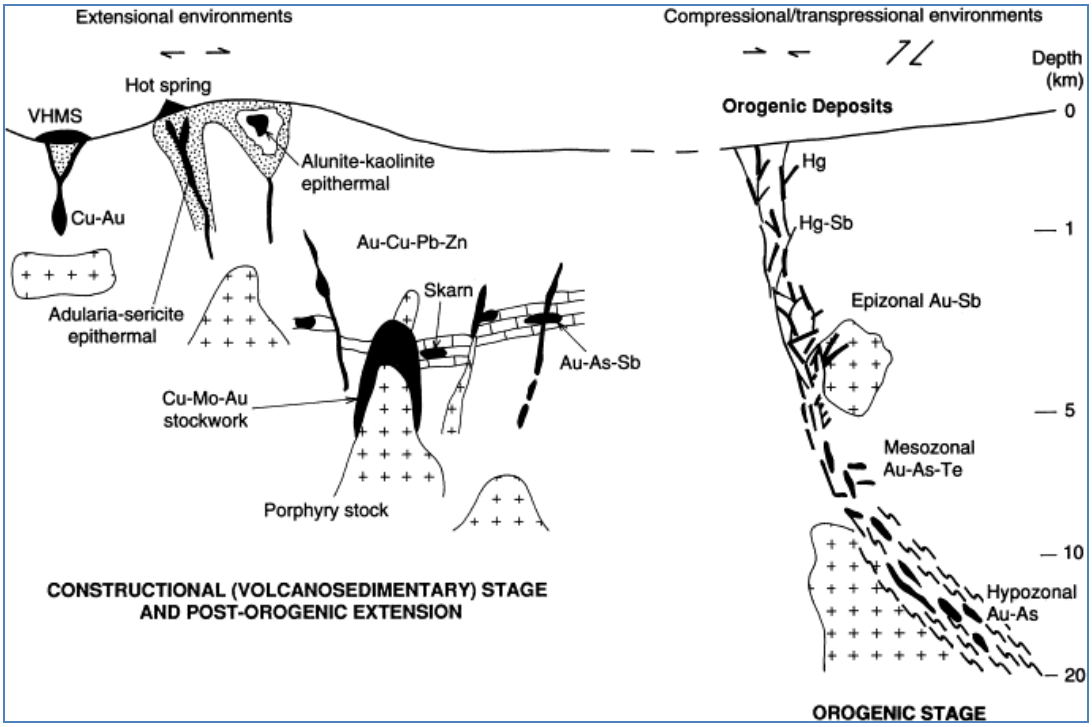
Stibnite can be very "in your face" and obvious to the naked eye. But it remains impervious to large-scale resource identification. One could spend a very large amount of money missing the veins by inches and the veins direction could be lost underground even if it gets wider and deeper and richer. Much of the most successful drilling of Antimony is done in underground mines where the drilling is done at the mine face to ascertain the vein direction and widths.

Thus Antimony remains largely elusive to the conventional approach of drilling the hell out of the deposit and having expensive consultants come up with a resource.. wash and repeat… *ad nauseam.*

On the contrary the way Antimony has been mined since time immemorial is to find an outcrop and start a mine. The mine then follows the vein(s) and wends its way underground merrily collecting the ore and sending it off for concentration and production. This is what made China Masters of the Antimony Universe.

Gold with Antimony *or* Antimony with Gold?

Many geologists have observed the association of Antimony with Gold deposits, such as in parts of Australia and North America. The classification of these deposits has often referred to the occurrence of Antimony (Sb) as in the orogenic models below for 'epithermal' style mineralisation.



Source: Groves et al. - Ore Geology Review 1997

The zonation is attributed to the various boiling points for the minerals, the lighter and nearer surface ones being Mercury (Hg) and Antimony (Sb) with deeper seated gold and then base metals lower down the system forming at higher temperatures and pressures. Therefore, antimony is often a geochemical indictor for most exploration geologists seeking epithermal gold occurrences.

Other gold deposit models that include antimony are the Carlin sediment hosted hydrothermal deposits of Nevada. Australia has many regions that host gold with Antimony occurrences including the Northcote district in Northern Queensland, the Indee district of the Pilbara, Victoria and the Au-W-Sb district in New South Wales.

Other countries and regions with gold – Antimony deposits include Serbia, Slovakia, Alaska, Canada (at West Gore) and South Africa (Consolidated Murchison).

The majority of gold plants recover the precious metal using a leaching agent of cyanide in solution. The occurrence of Antimony consumes the oxygen in the solution and hinders the leaching effect of cyanide on the gold ores. Therefore, many Antimony-bearing gold deposits have in the past had low overall recoveries for the gold by way of using traditional leaching methods. Often these processes were at the expense of Antimony which was not economic to recover.

It is interesting to note that the Chinese roasters/smelters have corralled much of the non-Chinese sourced Antimony occurring in gold ores by offering the gold credits back to the miners (e.g. Mandalay with their Costerfield Mine in Victoria, Australia).

Antimony – Critical or Strategic or Both?

China has a very strong position in Antimony and long has had. Indeed this is the metal it has been dominant in for the longest. However, like so many other resources this was squandered through overproduction, predatory pricing and high-grading. China now finds its domestic share of global production plunging and to prop up its dominance it has become a leading importer of artisanal and "conflict" ore from all around the world. It then processes this imported ore/concentrate and manages to hold a still dominant position in processed end-product Antimony Trioxide and other products.

Is the metal strategic? Thus far it does not have the type of applications that other high-tech metals possess but it is still a key component in the things it is used for and its long term application as an alloy with Lead in ammunition has not gone away.

Antimony is a strategic metal used to harden lead in ordnance and lead-acid storage batteries.

Antimony Trioxide is a fine, white powder that is used primarily in conjunction with a halogen to form a synergistic flame retardant system for plastics, rubber, fiberglass, textile goods, paints, coatings and paper. Antimony oxide is also used as a color fastener in paint, as a catalyst for production of polyester resins for fibers and film, as a catalyst for production of polyethylene phthalate in plastic bottles, as a phosphorescent agent in fluorescent light bulbs, and as an opacifier for porcelains.

Sodium Antimonate is primarily used as a fining agent (degasser) for glass in cathode ray tubes and as a flame retardant. Antimony Trisulphide is a major component in primers for all center-fired ordnance.

And now we have the latest new technology to utilize the metal that is Antimony molten salt batteries for mass storage. The potential here is for a quantum surge in demand. This new application may be its own undoing if the price of the metal goes too high and unravels the economics. Time will tell.

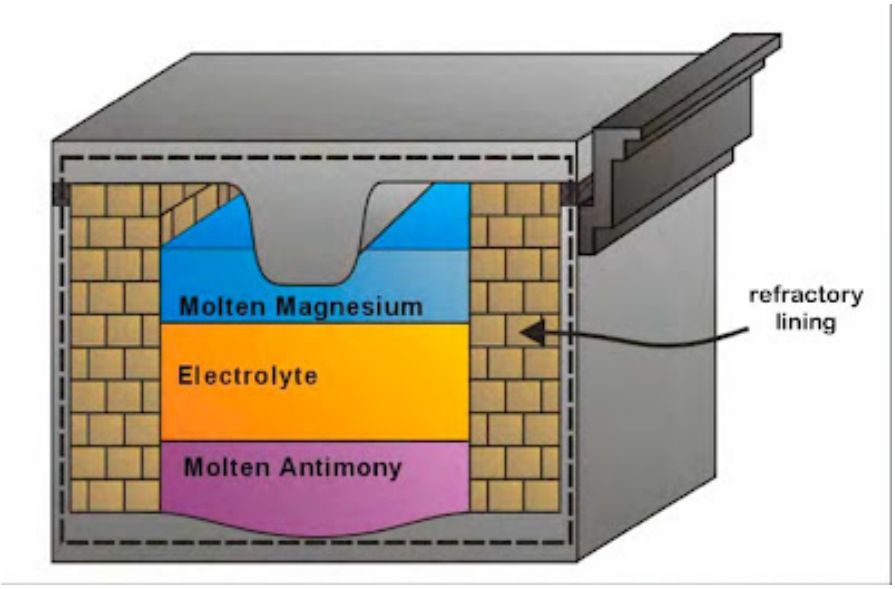
Mass Storage Devices

After a long period with no significant new applications for Antimony the appearance on the scene of Molten Salt batteries as mass storage devices has upset the delicate supply/demand balance in Antimony.

One of the prime attractions of mass storage devices is that they do not need to be connected to the grid and thus can be in the middle of nowhere bridging the infrastructure gap (and cost) that weighs on emerging economies (and isolated minesites). They can be supplied with the energy they store from solar or wind sources.

The most commonly touted medium for this type of storage is Vanadium Redox Flow batteries (VRBs) but now liquid metal batteries using molten salts are being added to the mix. The concept however is not new with the idea of using these salts for storing energy going back to the Second World War.

Molten salt is a solid at standard temperature/pressure but enters the liquid phase under elevated temperatures.



Liquid metal batteries can be stored indefinitely (over 50 years) yet provide full power in an instant when required. Once activated, they provide a burst of high power for a short period (a few tens of seconds to 60 minutes or more), with output ranging from watts to kilowatts. The high power is due to

the high ionic conductivity of the molten salt, which is three orders of magnitude (or more) greater than that of the sulphuric acid in a Lead–acid car battery

A team of researchers at MIT led by Professor Donald Sadoway worked on a liquid battery system that could enable renewable energy sources to compete with conventional power plants.

The research was put into a commercial venture, called Ambri, which was funded to the tune of $15mn by Bill Gates, energy giant Total, the US Department of Energy's Advanced Research Projects Agency and Khosla Ventures (run by Sun Microsystems co-founder Vinod Khosla).

What this means for Sb Demand

Each GWh of Ambri batteries requires less than 1% of current annual production of these (calcium and Antimony) anode and cathode materials. This is the closest we have to divining how much Antimony that the Ambri product line might consume if it gains traction. Current Sb production is around 170,000 tonnes per annum, implying that a Gigawatt of Ambri cell utilizes around 1,700 tonnes of Antimony.

Higher prices are rather a "chicken-and-egg" issue for the likes of Ambri. To be sure of adequate supplies of metal higher prices are needed (probably over $8,000 at least) and yet if they go too high then viability of the economic equation is cast into doubt.

If Liquid Metal Batteries become the "killer application" in grid-linked storage (or non-grid linked) then it potentially lights a fire under Antimony demand and pricing. The announcement that US Antimony (NYSE:UAMY) had secured an offtake deal with Ambri for its output lit a fire under the price of that stock in late 2020.

To mix some metaphors, molten salt batteries have flown under the radar thus far but definitely have a place in the evolving battery universe and hopefully will take the Antimony market along for the ride.

Lighting a Fire Under the Price

After a swoon that lasted several years, and sank the prospects of several Antimony wannabes, the price of Antimony started to uptick in 2016. It got to around $8,500 per tonne and then plunged again to around $5,800 on stories that the metal was about to be put in the penalty box by the EU and some American states. This was linked to supposed toxic properties when used in fire retardants, particularly with children's pijamas.

This was further complicated by the ever-looming liquidation of the FANYA stockpile, which amounted to around 19,000 tonnes, which was finally sanctioned by Chinese courts over the summer. The latest talk in the trade is that now the FANYA stocks have been bought by one of China's largest Sb producers.

The price (as shown in the chart on the following page) has taken off in recent times on a combination of global shortages caused by the Pandemic and the coup in Burma, long term underinvestment, declining Chinese production and the arrival of Molten Salt batteries in the commercial marketplace.

Source: Argus Metals

The effect was stunning, with Antimony breaking out of a multi-year malaise and becoming the hottest metal in the last six months (though tussling with Tin for that title) doubling in price from around $5,500 to nearly $11,000.

Pricing

Like so many other critical metals under the tender mercies of Chinese domination, the price took off, spiked and then eased back. It was trading at around $6,000 per tonne in 2008. It then soared in the first half of 2011 to just over $18,000, and then eased off, spending most of last year between $12,000 and $14,000. Currently it stands just below $10,000 per tonne.

On the Road to Mandalay

A good example of this is Mandalay Resources (MND.v). This company mines the Costerfield Mine outside Melbourne in the state of Victoria in Australia. This company produced 3,275 tonnes of Antimony in 2013 (and 50,000 oz per annum of gold). However the resource at the mine is only 15,300 tonnes. That is less than five years mine life (however up from a 16 month mine life in early 2013). The earlier resource was enough to give traditional mining investors a case of the vapors. And yet the stock soared from a market cap of $160mn in July 2012 to over $300mn in early 2013 when the mining markets had headed in the opposite direction. It is even slightly higher now despite the addition of substantial extra mine life. Why were investors not spooked by the low mine life? Maybe it helps to know that the deposit has been mined since the 1860s on and off…

Adroit (ADT.v) – But Not Dexterous

Adroit's Antimony assets consisted of the past-producing (up until the 1980s) mines in southern Tuscany. Before one rejects this idea with visions of ancient monasteries, vineyards and NIMBYs we would point out that this is the faded industrial part of Tuscany off the tourist's beaten path. Adroit have unfortunately "lost altitude" like so many others and seem to have drifted off in the direction of projects (non-Antimony) in Canada. At worst this leaves Adroit's Italian assets as open for other players to pick up.

Straits Resources (SRL.ax) – Dire Indeed

This ASX-listed stock has fallen on very hard times indeed. It was long the owner of Hillgrove gold/Antimony mine (on care and maintenance since 2008) in northern New South Wales. Several attempts were made to float off the asset but they coincided with dire financing conditions in the mining space (even though Antimony prices were good). They eventually succumbed to a low-ball sale. With some luck this mine will be back in operation in the not too distant future and might even pop up back in the public equities markets as an investable opportunity.

Reef on the Rocks?

The largest Antimony mine outside China is the Consolidated Murchison mine in South Africa, which is

owned by Village Main Reef (VIL.jse). It produces gold and Antimony and is a deep mine, a relative rarity in Antimony. Large scale mining began here in 1937, so again we have an example of a very long-lived Antimony deposit. When fully operational the mine adds around 6,000 tpa to global Sb supply. However Antimony production was only 1,289t for the six months ended 31 December 2013 compared to 2,728t for the six months ended 31 December 2012, a decrease of 53%, which was a direct result of a strike at the mine in July 2013. Production ceased in 2015. Strong murmurs exist that Village Main Reef has this asset up for sale. It supposedly has a remaining 11-year LOM.

The Exception – China's Mega-mine

The granddaddy of Antimony mines is the Hsikwangshan (Twinkling Star) Antimony Mine in China. It was originally found in 1541 when mining began, and it has been mined "formally" since 1897. This mine alone produces 25% of global supply (and may have made up an even higher percentage in recent decades). It was this mine that gave China the 90% market dominance in the Antimony space that it enjoyed for much of the period since the 19th century (until recently).

The Xikuangshan deposit lies along the F75 NS fracture some 9km – 10 km long with deposits forming along and at cross cutting fractures and folds such as F72 and F3. Fractures are more developed than folds and often predate mineralisation. These fractures played an important part in the transport and storage of mineralisation.

The main orebodies at the mine are stratoid or lenticular in shape with feathering like features into the joints and voids of the host limestones. The ore is primary stibnite with a little pyrite. Some antimony oxide was formed. The orebody strike was typically 400m to 600m long with widths of 2m to 7m and grades of around 4% Sb and always associated in a blanket of silica, as silicification is the main indicator for ore prospecting. The deposits were accessed by underground mining and at depths of 100m to 300m below surface. The deposit was thought to contain over 1.9 million tonnes of contained antimony in 2000. This has since been reduced due to ongoing production and the Chinese national reserves as a whole are estimated to be 0.95m tonnes of contained Sb, with Xikuangshan being still the dominant source producing around 40,000 tonnes of contained Sb per annum.

Admittedly this mine is special in that it is not only long-lasting but also high volume. However, even Antimony mines don't last forever and it is a widely held view that this mine is now in terminal decline with higher extraction costs and declining grades.

Risks

Until late 2020, Antimony was in one of its swoons that had lasted a few years. The FANYA threat was behind it, only to be replaced by the regulator threat (the EU and State of Massachusetts) agitating against fire retardants. This has gone back to being a sleeper issue (but could come back to life). In the last six months, as mentioned, prices have rebounded as Chinese production continues to decline and low prices have stymied anything beyond small-scale production outside China.

Conclusion

In this Third Wave of battery metals, Antimony (the prime component in Molten Salt batteries) has joined the ranks of battery metals and the hunt is on for that scarce commodity, the non-Chinese Antimony miner.

Despite all that such is the uplift that Antimony stocks can achieve in a market starved for options in this metal. The only other plays are the gold/silver miner, Mandalay Resources (MND.v) that has Antimony as a by-product from its Costerfield mine in the Australian state of Victoria, and US Antimony (UAMY) with its curious focus upon the Los Juarez Silver-Antimony mine in Mexico.

While the Antimony price was in somewhat of a regulator-induced swoon in the last two years, the main application in fire retardants has not gone away and in the wake of Grenfell Tower fire in London the regulators act against fire retardants at their own peril. In the wake of the pandemic and with the marketplace dry of product, the price has had a fire lit under it by Molten Salt batteries capturing the *Zeitgeist*. This combination was a perfect storm that drove the price from around $5,500 in late 2020 to double that level in recent weeks.

Thus, Antimony is a truly wonderful product to be mining when the price is up (as it is now, historically speaking). It also has a force field around it because the volumes are always too small to excite a major, while being impervious to any sort of large-scale resource identification it becomes anathema to the “drill it to death” crowd in Vancouver. Likewise as the best exploration in Antimony is mining itself it scares off the faker crowd who inhabited the Rare Earth space as they would be all too quickly exposed for the talkers (not doers) that they are. A typical Antimony mine is thus small, high-grade, underground with a short theoretical mine life which might very well go on “forever”.

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