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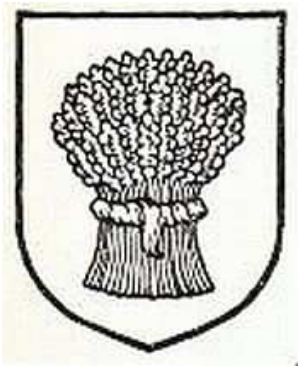

HALLGARTEN & COMPANY

Sector Review

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Scandium:
Enter RTZ…. as Godzilla

	Portfolio Call	Ticker	Price	12 mth range	Market Cap.
American Rare Earths	**Long**	ARR.ax	$0.10	$0.011-$0.235	AUD$32mn
Australian Mines	**Neutral**	AUZ.ax	$0.02	$0.006 -$0.04	AUD$91mn
CleanTeQ	**Long**	CLQ.ax	$0.30	$0.65 - $1.78	AUD$261mn
Imperial Mining	**Neutral**	IPG.v	$0.19	$0.03 - $0.235	CAD$24mn
Niocorp	**Short**	NB.to	$0.86	$0.53 - $1.02	CAD$207mn
Platina Resources	**Neutral**	PGM.ax	$0.05	$0.01 - $0.082	AUD$22mn
RTZ	**Unrated**	RIO.ax	$127.50	$72-$129	AUD$206bn
Scandium Intl	**Long**	SCY.to	$0.24	$0.055 - $0.35	CAD$75mn

Scandium

Enter RTZ… as Godzilla

- + RTZ have shown their hand in the space with a plan to start producing Scandium from Titanium streams/waste in Quebec
- + This development lays to rest the long-time bugbear of unavailability assuring potential users, like big aerospace companies, of future supply from a reliable source
- + Strong potential for expansion of demand based upon increased availability at current or lower prices – applications follow supply
- + Perversely, RTZ entering the space is good for juniors as it will spur expansion of usage and in turn raise demand and bring Scandium into the mainstream
- ✘ Financing environment remains challenging
- ✘ Some of the new projects are predicated by Cobalt as a by-product and that metal has been trading at low prices after crashing and burning in 2017/8
- ✘ With seven Scandium hunters already in the race there is a lot of noise and misinformation but there is also a higher profile for what has hitherto been an obscure metal

The Eternal Chicken or Egg Dilemma

The problem potential end-users of Scandium have is that a chicken-or-egg-like dilemma arises. Does a major aircraft manufacturer tool up for a switch to Scandium in its Aluminium alloy usage when it can be guaranteed little more than scraps in the current scenario? While for potential miners the dilemma is do they build a mine on faith alone that end-users will tool up even when there is a reliable source of Scandium in size? For end-users there is another dilemma. Do you rely upon only one supplier when that miner is more subject to the vagaries of the Nickel price than the Scandium price? If Nickel prices deteriorate for whatever reason then a Scandium source could be shuttered as it is only a by-product.

The evolution of the Scandium space we have long-posited is that a would-be producer of Scandium as a by-product, would produce several tens of tons per annum and then escalating, with a primary producer (or two) probably then joining the fray. Scandium, in that circumstance, goes from being an “obscure object of desire” in high-tech industries to being a conventional specialty metal like Tungsten or Tellurium.

In recent weeks we have seen a major, RTZ, step into the space in a potential game-changing development for Scandium and its applications and adoption.

In this review, we shall look at the implications from this development and the state of play for the metal.

On Scandium

At the time, some of the more ignorant of the mining space referred to Scandium as one of the Rare Earths despite it not belonging to the Lanthanide series and rarely appearing in their company in mineralisations. We note with some amusement that the latest swathe of US tariffs against Chinese metals exports targeting Rare Earths, repeat the error and include Scandium in the targeted metals, despite China (to our knowledge) not being a notable producer of Scandium and certainly not an exporter of any note.

Despite this Scandium seems, in fact, to be the closest thing that we have to *Unobtainium* with its very scarcity being its own worst enemy. This is a situation that seems on the verge of being remedied from an unexpected quarter, i.e. RTZ's move into the space.

The potential of Aluminium Scandium alloys in the aerospace and transportation industry has been well understood for decades. But what has likely been lacking is a clear path to the supply growth needed from the current tens to hundreds of tons of oxide per year, and with it a production cost basis to support a mass application where development timelines run into decades.

It has the potential to provide light-weighting properties to rival composites and Titanium alloys across a wide range of applications. But much depends upon the eventual price because there has never been an organised transparent market as both production (by-product) and demand have been low volume and opaque. And as Scandium has been produced occasionally as a by-product of Rare Earth mining it was exposed to the same volatility risks as Rare Earth prices, which spiked in 2010 on political factors and then slumped.

The Friedland Effect?

Scandium was, until 2017, one of the lesser talked about technology metals. Since then it has received increased focus and mention, not least because of the peripheral involvement of Robert Friedland in the metal. This interest is despite the fact that the supply situation is severely limited with literally only a few tons of product hitting the market per annum, and even that is as a by-product of the refining and processing of other metals. The applications for the element are known, particularly in Aluminium alloys, solid oxide fuel cells and lighting but it's just that manufacturers will not tool up for the metal if they cannot be guaranteed greater (reliable) supply.

Applications

The largest current user of Scandium, as we noted in our coverage of Bloom Energy (NYSE:BE) last year, is this producer of solid oxide fuel cells (SOFCs). Scandium-stabilized zirconia (ScSZ - usually 9 mol% Sc_2O_3 – 9ScSZ) enjoys a growing market demand for use as a high-efficiency electrolyte in SOFCs, including those of the leading commercial supplier, Bloom Energy. These natural gas powered electrical generation systems are highly efficient, reliable, clean, and completely independent of traditional electrical grid systems.

The SOFC business has been the fastest emerging application, accounting for maybe as much as three quarters (in some estimations) of the current world Scandium consumption.

Traditionally the main application of Scandium, by weight, has been as a grain-refining agent in Aluminium-Scandium alloys for minor aerospace industry components. The positive effects of Scandium on Aluminium alloys were discovered in the 1970s. These alloys, composed of as little as 0.5% Scandium, make a significant difference in strength. It can be added to most of the standard alloy grades to improve tensile strength, corrosion resistance, weldability and heat working tolerances. It reduces temperature creep in alloys, and combines particularly well with magnesium and zirconium to add unique enhancements to alloy performance. Scandium does not reduce electrical conductivity in aluminum alloys to the extent other alloy combinations suffer degradation.

Aircraft designers in constant search for performance gains with weight reduction (with no performance loss) being the key goal.

- ✓ Weight loss improves range, payload capacity and economy
- ✓ One kilo of weight savings in an aircraft = $60 p.a. fuel saving ($1/gal)
- ✓ AlMgSc alloy payback is < 1 year (10% weight reduction assumption)

Aircraft materials costs are secondary to performance.

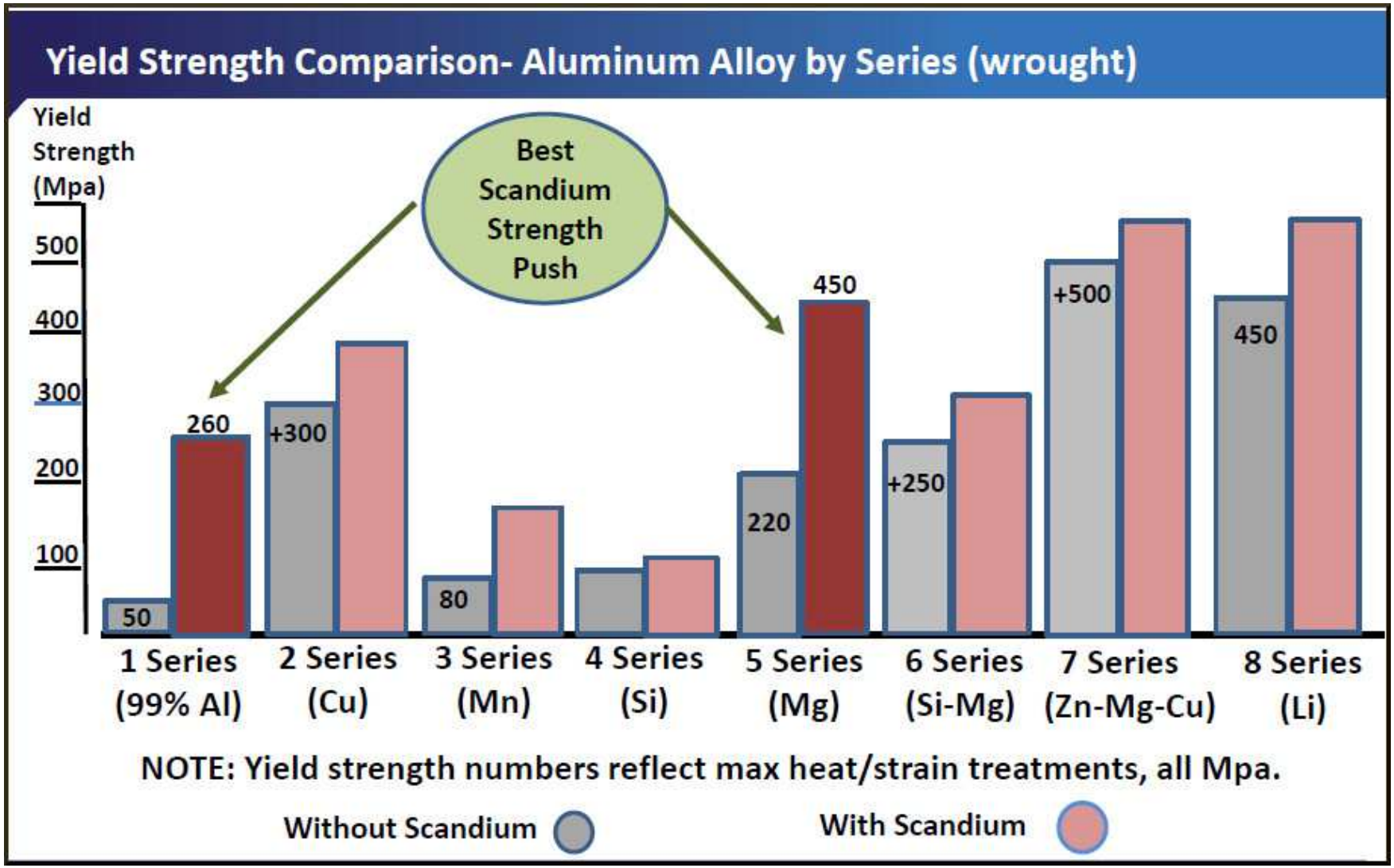
- ✓ Single aisle plane (US$100mn) contains about US$300k in Al alloy
- ✓ Designers predict 15-20% lower weight + lower mfg. cost using AlMgSc
- ✓ Maximum scandium additions would cost $200k-$300k. (50kg/$100k)

Alloy cost is often not the driver in other industries as well. For example:

- ✓ Bicycle frame (high-end) alloy @ <1% cost Sc addition = 1.5%
- ✓ Automobile parts properties will drive selective adoption

Thus Aluminium Scandium alloys could find a new growth area in the electric vehicle (EV) industry, which is the major demand driver for Rare Earths. In electric and hybrid vehicles weight reduction is critical to reducing the size and cost of batteries. And EV materials need stronger resistance to electricity and corrosion. Competition between structural materials, metals, alloys and composites is intense, and the demands on their properties across all sectors will only increase.

On the following page can be seen a comparison of various Scandium alloys by strength:



Source: Scandium International

One area that intrigues us is the Sc_2O_3 that is used annually in the United States to make high-intensity discharge lamps. Scandium iodide, along with sodium iodide, when added to a modified form of mercury-vapor lamp, produces a form of metal halide lamp. This lamp is a white light source with high color rendering index that sufficiently resembles sunlight to allow good color-reproduction with TV cameras. The USGS estimates that around 80 kg of Scandium is used in metal halide lamps/light bulbs globally per year. This would seem to be an application where a greater, more reliable supply of the metal might result in a significant expansion in usage, particularly into more household applications. We could also see potential in sports arena lighting.

Another little-recognised application, that should be on the rise over the next few years, is the use of Scandium in switches in 5G networks.

Even more obscurely, Scandium also has uses in sports equipment, guns and dental inputs. Some of its applications though can be substituted with Titanium.

Build It and They Will Come?

The absence of reliable, secure, stable and long-term production has limited commercial uptake of Scandium. Despite this low level of use, Scandium offers significant benefits. The potential for substantial expansion in usage and demand clearly exists and to an extent it is one of those “rare” metals stories where the supply could potentially generate the demand rather than the other way around. The most obvious areas where this might happen are in lighting systems, SOFCs and Aluminium alloys.

In some ways a good analogy might be Europium. Its application in colour televisions spurred a surge in REE mining (ironically at Mountain Pass) which then made the “rarer” REEs more abundant, lowering the price but moreover accentuating the supply which meant that new applications arose or were employed that spurred the whole evolution of the permanent magnet and laser usages of the other metals in the Lanthanide series.

It is not too difficult to imagine that greater production will firstly spur the master alloy applications, followed by an expansion in the SOFC demand, lighting and then “new” applications. In aircraft alone the Aluminium alloy demand might totally consume the entirety of the extra metal that nascent producers might bring to market. It is interesting to note that Bloom, probably the world’s major consumer of Scandium, came to market in an IPO in 2018. We undertook a word search of the prospectus yielding no result for Scandium, not even in the risks section.

The Earth Shakes for Scandium

Rio Tinto has gone from zero to 100, in no time at all, in the thin and opaque Scandium space…. Or at least it is threatening to. The company has announced that through the reprocessing of residues from the Aluminium smelting process it intends to become the world's first large producer of Scandium, which is starting to obtain recognition as a critical metal on which the US, in particular, has an

exceptionally tenuous hold despite being the largest consumer, through it pivotal role in the production of Solid Oxide Fuel Cells (SOFC) and the growing recognition of its role in switches in 5G networks.

It is not breaking the mould though as it too will be a secondary producer of Scandium like all the current players as none of the primary Scandium mines have managed to get escape velocity from high-capex requirements or flaccid financing markets over the last ten years.

Todd Malan, RTZ's Rio Tinto's vice-president for corporate relations, told delegates at a recent joint US-Canadian government online conference on supporting critical mineral supply chains that: "We are progressing plans for industrial-scale production that will draw on Rio Tinto's position as a leading Aluminium producer to provide not only a reliable source for Scandium oxide from North America but also for Aluminium Scandium alloys".

Rio Tinto is producing Scandium oxide to commercial specification and Aluminium/Scandium alloy at a pilot plant at its Sorel Tracy metallurgical plant in Quebec. Located 70km from Montreal, Sorel Tracy processes ore from the Havre-Saint-Pierre mining complex in eastern Quebec province.

RTZ has said that it is in advanced discussions with potential customers. The company is using a process developed to extract it from waste streams from the plant, which produces Titanium dioxide feedstock, pig iron, steel and ferrous powders. This might spur other majors, such as Norilsk, to set up circuits or plants to extract Scandium from their product streams.

The Scandium Space

When we first wrote on this metal Scandium International (SCY.to) was quite clearly a lone voice in the wilderness. Since then a number of other wannabes have appeared touting their Scandium virtues as either byproduct kickers or attempts to make unviable and unsexy projects (pardon our cynicism) into viable and sexy propositions to potential investors. In some cases they have attracted investor attention and have had the positive effect of making the metal more high-profile than it has hitherto been. At a workshop we attended at the European Space Agency, Scandium was the metal that was most mentioned with Tellurium a very distant second.

Bizarrely the Scandium space is currently being fought over like some ridge in a First World War battle in Flanders. This might be understandable if the price of the metal was raging higher but price is one of the most obscure elements of this element. We know it is highly valued but that is a product of its scarcity. There are few metals out there in which economic models and extant production plans actually guarantee a fall in the metal's price if plan are realized, even in part.

The players in the Scandium space are concentrated in Australian properties, with three claimants that we know of, presenting properties in North America. The seven are:

- CleanTeq (the Syerston project in NSW)
- Scandium International (the Nyngan project in NSW)

- Imperial Mining (the Crater Lake project in Quebec)
- American Rare Earths (the La Paz project in Arizona, USA)
- Platina Resources (the Owendale project in NSW)
- AusMin (Flemington project in NSW)
- Niocorp (the Elk Creek project in Nebraska, USA)

The players are summarised in this table:

	Ticker	Location	Project	Mineralisation	Capex	Sc Grade ppm	Sc Contained Tonnes
Australian Rare Earths	AUZ.ax	USA	La Paz	Sc/REE		14	1,612
Australian Mines	AUZ.ax	Australia	Flemington	Co/Sc/Ni		404	1,091
CleanTeq	CLQ.ax	Australia	Syerston	Ni/Co/Sc	US$1.33bn	421	19,240
Imperial Mining	IPG.v	Canada	Crater Lake	Sc/Ti/Zr			
Niocorp	NB.to	USA	Elk Creek	Nb/REE/Sc	US$879mn	72	2,266
Platina Resources	PGM.ax	Australia	Owendale	Sc	AU$68mn	395	14,418
Scandium Intl	SCY.to	Australia	Nyngan	Sc	US$87.1mn	235	3,976

Scandium Volumes – A Relatively Unknown Quantity

The USGS has estimated that global Scandium consumption was less than 10 tons per year in 2013. However, as this metal is one of the least intermediated metals around (i.e. most of its trade is directly between end-users and the "producers", one has to wonder how reliable the USGS numbers are. We have spoken to knowledgeable parties in the Scandium trading space that estimate it at 20-25 tonnes per annum. We suspect it is now closer to 30 tonnes.

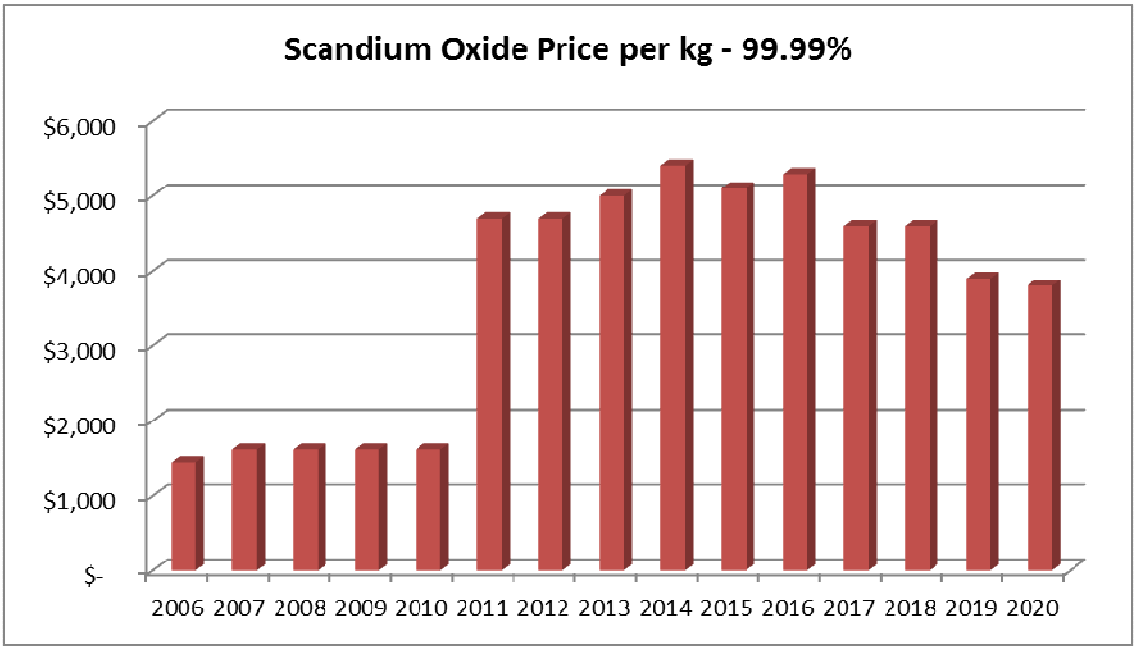
Prices & Marketing

The current price of the metal is another murky area (even more so than many of the minor specialty metals) with indications that Scandium Oxide traded at over US$5,000 per kg in the middle of the decade. This compares with $1,620 per kg as recently as 2010.

Pricing in the metal is somewhat of a "nod, nod, wink, wink" process. One Scandium watcher we spoke to commented that he thought that "$900/kg was a low-wrong number in 2009, and $5,200/kg is a high-wrong number in 2016".

Since then prices have undoubtedly gone down with everyone getting it (except maybe at Niocorp who "didn't get the memo" or it didn't suit them to read it). The USGS is, alas, the most public price-taker in the Scandium space and yet it seems to be quite out of touch with reality. In fact the disparity with the word on the street is startling, implying that the USGS should either improve its sources or desist from guesstimating for the metal.

On the following page can be the price estimates in their version:



Source: USGS

Speaking to an informed player in the space he noted that Chinese oxide is cheap, maybe US$1200 or less, however master alloy is priced in a wide range. For small lots (50kgs or less) the metal can be obtained for $800 per kg, ex-China.

It is important to note that at $2,000/kg oxide pricing, there is US$66 of Scandium in one kg of Al-Sc 2% master alloy. There is no reason that Al-Sc master alloy margins should be more than a few dollars premium to other varietals.

Another issue of note is the grade differences in the quotes between 99% and 99.99%. Electrical uses will need 99.9%. Master alloy producers will be content with 98%, and they probably could do with 95% if they adjusted their mixing and dross management techniques. Most material will go into alloys.

In its DFS from June 2018, CleanTeQ made the comment, "While Scandium oxide prices have historically ranged from US$2,000-4,000/kg, the DFS has assumed a forward price of US$1,500/kg, which is the price at which the company expects significant additional demand growth to be stimulated".

Risks

It is important to highlight some of the risks in for Scandium players. At least with most players located in the well-known and long established mining jurisdiction of NSW, it is unlikely that any problems should present themselves on that front. However one should consider:

- ✘ Financing difficulties
- ✘ Scandium price fluctuations in what is an opaque market

- Price fluctuations for other metals that are primary drivers in some projects (i.e. Nickel & Cobalt)
- Failure of demand to match rising production (i.e. build it and no-one comes)
- Excessive number of competing projects could crowd the scene and hog capital

The chief advantage that CleanTeQ and Scandium International have in minimizing these risks is that they are so far advanced compared to other potential players, while in the case of Scandium International its bite-sized capex makes it eminently more buildable than some of the other contenders.

One thing that has become clear to us is that for end users to tool up for a shift to Aluminium-Scandium alloy use in serious quantities (ergo the aerospace industry) there will need to be at least two producers. One alone will not give them comfort of supply.

CleanTeQ, for instance, might start producing but if Nickel (or Cobalt) prices tank such a mine would be shuttered for the duration and the Scandium by-product users would be hung out to dry. This would be the point at which other primary mines for Scandium are "enabled" (such as Nyngan and Crater Lake) to give end-users diversity of supply and a source decoupled from the vagaries of the Nickel market.

Conclusion

Scandium has gone from being obscure a couple of years ago to be name-checked frequently in recent times. The irony was that the talk was much ado about nothing as long as the prospect of any decent boost to supplies remained merely a pipedream.

However with RTZ's push (and recognition) the *Wundermetall* has moved into the realm of the possible. The challenge has been that end-users wanted it but weren't prepared to back projects to make it happen. They were happy to talk but talk doesn't put metal on the table. Ironically it long seemed like new supply would come from the linkage to the fortunes of Cobalt and the rise of EVs potentially firing up the production prospects of Nickel/Cobalt mines with Scandium by-product credits. Recent events mean that it might be Titanium streams that eventually bring home the Scandium bacon.

Excepting Scandium International as the only primary Scandium player, the others are all viewing Scandium as a by-product for projects. Certainly, for a while there, the heat generated by Cobalt meant that projects with that metal could promote their virtues while overlooking the fact that Nickel had improved but not to levels where laterite Nickel projects would stand on their Nickel merits alone. The downfall of Cobalt derailed putative Ni-Co-Sc plays such as CleanTeq despite the project having the added zest provided by having Robert Friedland on board.

If this hubbub of arm-wavers has any usefulness it is in making Scandium the word of the moment amongst the chattering classes of the mining world. Unfortunately the average (or even the sophisticated) investor finds it difficult to discriminate between the good, bad and the indifferent. The more information that is available on the metal, and the dynamics, then the sooner this fog shall lift.

Scandium's potential for much greater penetration of the technology metals space is well-known to any

with more than a passing knowledge of the applications to which it can be applied. The move by RTZ into the metal is pivotal and probably ensures that Scandium can make the jump from being *Unobtainium* to being a commonplace specialty metal even if not in everyone's home or garage.

Important disclosures

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