AUXICO RESOURCES

THE FUTURE OF SUPERALLOYS: APPLICATIONS OF ENERGY METALS FOR STEEL AND ALUMINUM

SUPER ALLOYS ARE THE FUTURE

Superalloys, or high performance alloys, are alloys that exhibit excellent mechanical strength and creep resistance at high temperatures, good surface stability, and corrosion and oxidation resistance. The corrosion-resistant superalloys are widely used in extreme environments where tremendous heat and corrosion resistance is paramount to the integrity of the end product. Chemical and petrochemical processing, power plants, and oil and gas industries widely use these superalloys.

THE NICKEL SUPERALLOY

The nickel-based superalloys contain carefully balanced alloying additions of chromium, cobalt, aluminium, titanium and other elements.

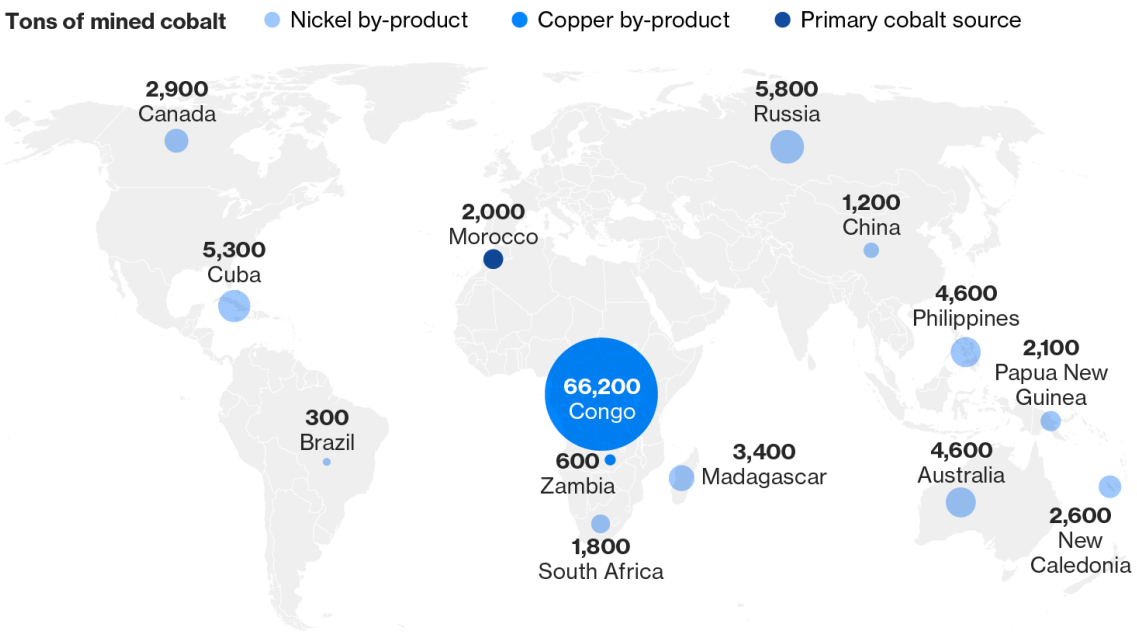
EXAMPLE: Hastelloy C276 is a nickel-molybdenum-chromium superalloy with an addition of tungsten designed to have excellent corrosion resistance in a wide range of severe environments. Alloy C-276 is widely used in the most severe environments such as chemical processing, pollution control, pulp and paper production, industrial and municipal waste treatment, and recovery of sour natural gas. Incoloy® is a nickel-iron-chromium alloy, relatively easy to fabricate, and can be made using the same machines and processes used to make stainless steel. Incoloy® is not suitable for severely corrosive environments, but some grades have been designed for increased corrosion resistance, even in harsh environments. Incoloy's® high temperature strength and resistance to seawater, brine, sour gas, and chloride make it ideal for use in the oil and gas industries, used for propeller shafts, hot vessels for food and water, chemical processing equipment, gas turbines, aircraft, and tank trucks.

COBALT: THE MOST IMPORTANT METAL OF THE 21ST CENTURY

Both the US and China consider it a *strategic metal*. This has caused the cobalt price to quadruple in the last two years, but this is only the beginning. By 2030, global demand could be 47 times more than it was in 2017 (Bloomberg New Energy Finance estimates*). In 2017, the world produced just over 100,000 tons of cobalt. Of this, 50% went to producing rechargeable batteries, and the other 50% went predominately to mission critical industrial applications, such as jet engine turbines and high-speed drill bits.

Cobalt Means Congo

Last year around 63 percent of the global cobalt supply was mined in the Congo



Source: Darton Commodities Ltd

Bloomberg

Fig 11 Cobalt supply-demand balance

Cobalt Demand (t)	2012	2013	2014	2015	2016	2017F	2018F	2019F	2020F	2021F
Superalloys	13,115	14,595	15,750	16,264	16,755	17,261	17,508	17,737	17,981	18,202
Batteries	30,600	32,900	39,100	41,055	43,108	47,419	49,552	52,030	54,111	56,005
Dyes & Paints	6,178	6,363	6,554	6,620	6,818	7,023	7,233	7,450	7,674	7,904
Catalysts	2,233	2,345	2,521	2,647	2,779	2,918	3,064	3,217	3,378	3,547
Other Chemicals	7,977	8,417	8,864	8,991	9,318	9,662	10,097	10,445	10,807	11,125
Magnets	3,623	3,405	3,473	3,543	3,649	3,686	3,722	3,760	3,797	3,835
Diamonds & Hard Facing	8,964	9,144	9,144	9,235	9,327	9,421	9,515	9,610	9,706	9,803
High Strength Steel	1,660	1,710	1,744	1,709	1,709	1,726	1,744	1,761	1,779	1,779
Total Demand	**74,350**	**78,879**	**87,151**	**90,064**	**93,464**	**99,115**	**102,436**	**106,011**	**109,233**	**112,201**
% change YoY	10.4%	6.1%	10.5%	3.3%	3.8%	6.0%	3.4%	3.5%	3.0%	2.7%
Primary/Secondary Cobalt Supply (t)	**2012**	**2013**	**2014**	**2015**	**2016**	**2017F**	**2018F**	**2019F**	**2020F**	**2021F**
Zambia	5,735	5,000	4,317	2,997	3,500	3,500	3,500	3,500	3,500	3,500
DRC	2,999	3,000	3,300	3,300	1,900	3,500	3,500	3,500	3,500	3,500
Russia	2,186	2,368	2,302	2,040	3,200	3,200	3,200	3,200	3,200	3,200
India	580	295	100	150	100	100	100	100	100	100
China	29,725	33,200	35,400	44,100	47,000	51,500	53,500	54,588	55,702	56,845
Finland	10,547	10,010	11,452	8,582	11,000	11,000	11,000	11,000	11,000	11,000
Australia	4,869	4,981	5,419	5,150	3,000	2,100	2,100	2,100	2,100	2,100
Canada	5,682	5,559	5,261	5,591	5,900	6,150	6,150	6,150	6,150	6,150
Secondary sources	2,800	3,050	3,050	3,050	3,000	3,000	3,000	3,000	3,000	3,000
Other	10,942	14,331	15,845	17,389	18,155	15,551	15,501	15,669	15,641	15,613
Total Supply	**76,065**	**81,794**	**86,446**	**92,349**	**96,755**	**99,601**	**101,551**	**102,806**	**103,893**	**105,007**
% change YoY	0.7%	7.5%	5.7%	6.8%	4.8%	2.9%	2.0%	1.2%	1.1%	1.1%
Balance	**1,715**	**2,915**	**-705**	**2,285**	**3,291**	**486**	**-885**	**-3,205**	**-5,340**	**-7,194**
Stocks	26,627	29,542	28,837	31,123	34,414	34,900	34,015	30,810	25,470	18,277
Weeks of Consumption	18.6	19.5	17.2	18.0	19.1	18.3	17.3	15.1	12.1	8.5

Source: CDI, CRU, Macquarie Research, February 2017

ROLE OF RARE EARTH METAL NIOBIUM IN THE NICKEL SUPERALLOY

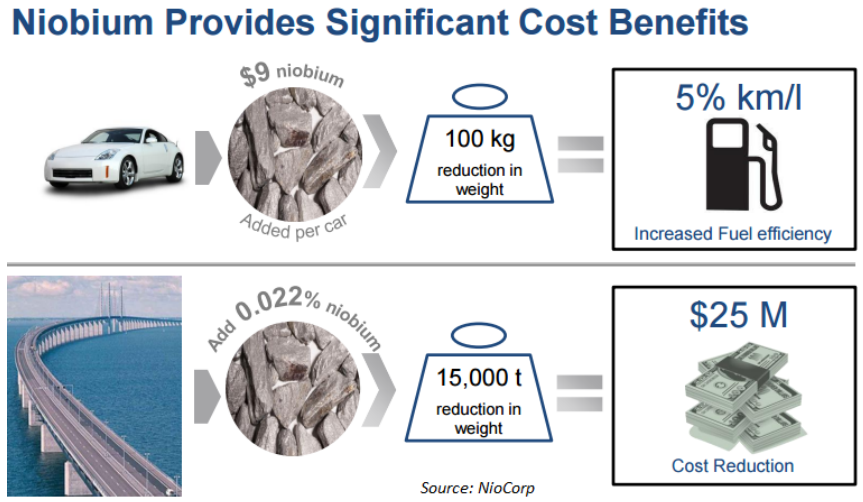
Considering solution heat-treatment, niobium increases solvus temperature, avoiding the dissolution of this phase at lower temperatures, also niobium promotes hardener effect at higher temperatures by increasing its volume fraction and thermal stability. For this and other reasons, about 50% of casting nickel-based superalloys has between 1.0 and 2.5 wt. % of niobium. About 85% to 90% of **niobium** in the world is used for iron and steel production as a form of **niobium** iron. The steel can increase more than 30% of strength by adding 0.03% - 0.05% niobium. Nickel-based superalloys used for turbine blades in aerospace engines or power generation use Nb concentrations up to 5.5%. Aerospace industry is the main application area of high purity niobium, mainly used for manufacturing engines and heat resistant components rockets and spacecraft. NB - and Ta - based hot - alloys have excellent thermal and thermal resistance and processability, which are widely used in aircraft components and gas turbine blades. In the United States, almost all jet fighter engines are made of niobium alloy. The price of Nb has remained relatively constant around 40 US$ per kg since 2000.

U.S. DEMAND SKYROCKETS FOR NIOBIUM: SOURCED ANYWHERE BUT CHINA

United States President Donald Trump this week signed into law the John S. McCain National Defense Authorization Act which sets an increased budget for defence expenditure. Section 871 of the act prevents purchase of rare earths magnets from prohibited countries, like China, Russia, North Korea and Iran. Currently China produces 85-90% of the world's rare earth magnets, some 90% of rare earths magnets consumed by the US military are produced by China, world demand is outstripping supply and a shortfall of rare earths magnets is predicted by 2020. Niobium, Scandium, and Titanium, in this case – that all have key uses in national defense and civilian technologies and upon which the U.S. is currently 100% dependent on foreign nations such as China and Russia. Niobium is used in bridges and other large infrastructure projects, in high pressure oil and gas pipelines, in virtually all steel-chassis vehicles, and in many other applications; $9 of Niobium added to a mid-sized automobile reduces its weight by 100kg, increasing fuel efficiency by 5%.

CHINA HAS ITS OWN ISSUES: Due to the scarcity of tantalum niobium resources in China, tantalum niobium ore has low grade, and tantalum niobium is heavily dependent on imports. BOTH RARE EARTH METALS HAVE LOW RECYCLING RATES Co (16%), Nb (11%); China's Rare Earth Industry Association has forecast that the use of REE oxides in China will increase to 149 000 t by 2020, while it was only 98 000 t in 2015, and certainly not enough supply to meet the growing infrastructure needs of the country.

THE NIOBIUM MARKET IS EXPECTED TO EXPAND AT A CAGR OF OVER 6.88% DURING 2018-2023 NIOBIUM, A RARE-EARTH ELEMENT, IS USED MOSTLY IN THE FORM OF FERRONIOBIUM BY THE STEEL INDUSTRY, EMPLOYED AS NIOBIUM ALLOYS AND METAL BY THE AEROSPACE INDUSTRY.



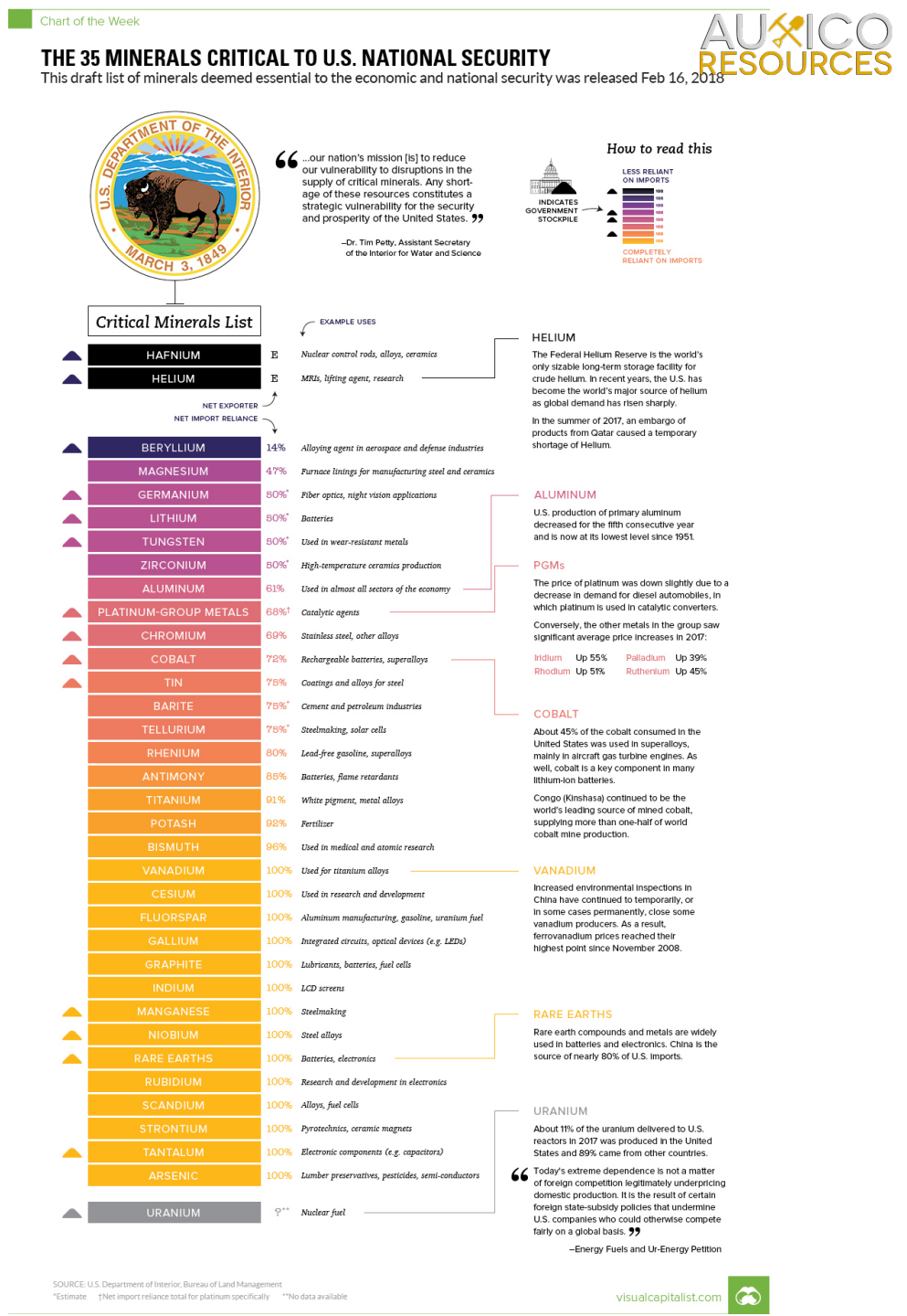
REPORTS FROM THE U.S. GOVERNMENT OF DEFENCE STATE THAT RECENT TARIFFS ON STEEL AND ALUMINUM PRODUCTS CONTAINING STRATEGIC AND RARE ENERGY METALS ARE A RISK TO NATIONAL SECURITY

Military and industrial leaders have begun raising concerns over groups of raw materials known as Rare Earth Elements (REEs). REEs used to be predominately sourced from NATO member nations, with the U.S. producing the majority of global supplies until the 1980s. China now supplies 95% of REEs globally, and has hinted at possible strategic hoarding of these critical minerals. To pre-empt possible shortages in critical defence technologies. REEs consist of a group of 17 elements, 15 of which are grouped together as the Lanthanides on the periodic table of elements, as well as Yttrium and Scandium, which share similar chemical properties. Defence analysts are particularly interested in REEs due to their use in military applications such as missile circuitry and telecommunications equipment. The U.S. Government Accountability Office (GAO) has stated that it would take 15 years to overhaul the defence supply chain to adequately prepare for large scale changes to current sources. Like many specialty minerals, REEs have a considerable lead-up time before their production can be streamlined post-development of a viable deposit. According to the USGS, the country sources at least 31 of the aforementioned materials chiefly through imports.

Energy	Technology	Industrial	Steel	Batteries	Research
HAFNIUM	GERMANIUM	BERYLLIUM	MAGNESIUM	LITHIUM	HELIUM
RHENIUM	INDIUM	ZIRCONIUM	CHROMIUM	COBALT	RUBIDIUM
TANTALUM	GALLIUM	TUNGSTEN	TIN	ANTIMONY	CESIUM
URANIUM	RARE EARTHS	ALUMINUM	TELLURIUM	GRAPHITE	BISMUTH
		PGMs	MANGANESE		
		BARITE	VANADIUM		
		FLUORSPAR	NIOBIUM		
		ARSENIC			
		SCANDIUM			
		STRONTIUM			
		TITANIUM			
		POTASH			

AUXICO HAS ENTERED INTO A JOINT VENTURE AGREEMENT WITH CENTRAL AMERICA NICKEL WHO HAS DEVELOPED A PATENT-PENDING RECOVERY PROCESS, THE ULTRASOUND ASSISTED EXTRACTION TECHNOLOGY (UAE), DEMONSTRATING THE ABILITY TO RECOVER OVER 90% OF NICKEL, COBALT, MANGANESE AND VANADIUM IN LESS THAN 1 HOUR, ALONGSIDE OTHER METALS, WHILE USING NO HEAT AND NO PRESSURE.

NOT ORIGINAL AUXICO CONTENT, INFORMATION PULLED FROM VARIOUS SOURCES



AUXICO RESOURCES

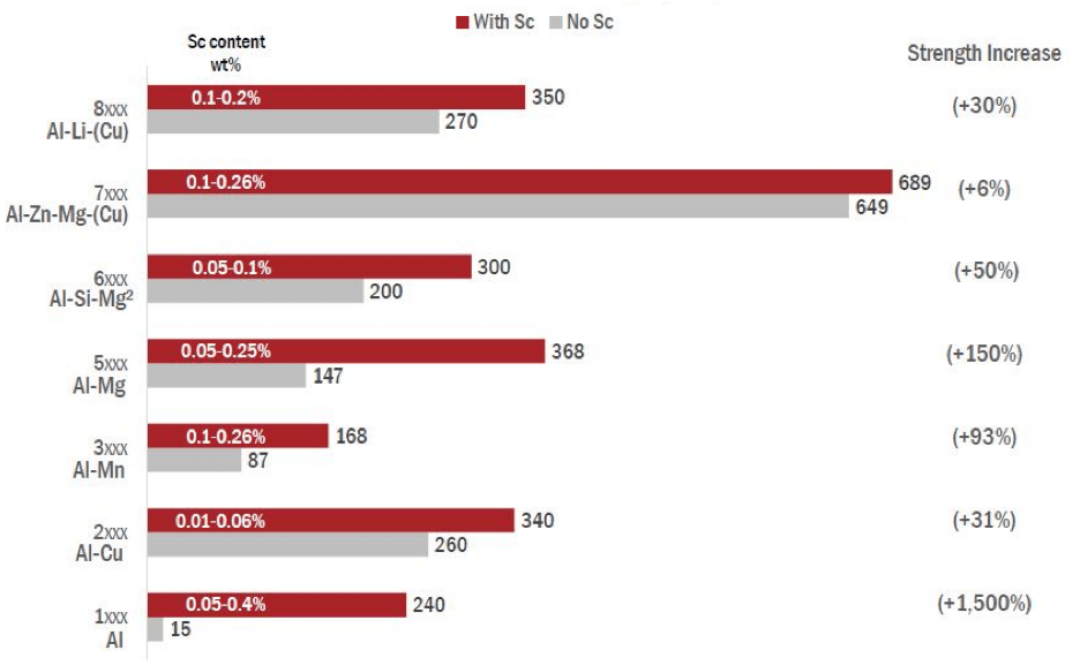
SCANDIUM AS STRATEGIC METAL AEROSPACE AND DEFENCE

LEVERAGING EMERGING TECHNOLOGY SUPER ALLOY COUPLED WITH PATENTED ULTRASOUND ASSISTED EXTRACTION TECHNOLOGY

Global yearly demand for the metal is relatively very small, around 20 tonnes. The reason for this is usually found in scandium's low concentration and its difficulty in separating it from the ore, pushing costs to elevated levels (according to recent figures, around US$7000 /kg of concentrate), thereby hampering its commercial use. AUXICO maintains a joint venture agreement with CAN, whereby their patented ultrasound assisted extraction technology resolves separation concerns with 98% success rate, and has access to 6,000 tonnes of Scandium through it's strategic partnerships, with 100% recovery of Scandium.

Very little amount of scandium is needed to improve aluminium alloys properties, less than 1wt% (weight percent). For instance, alloying scandium with aluminium-magnesium alloy increases its yield strength by up to 150% while preserving density and resistance to corrosion. In addition, scandium increases the quality of the alloy's welded joints, avoiding cracking at welds and decreasing fatigue life by up to 200%. This recommends Al-Sc alloys as an excellent choice for wider use in automotive industry in perspective (future).

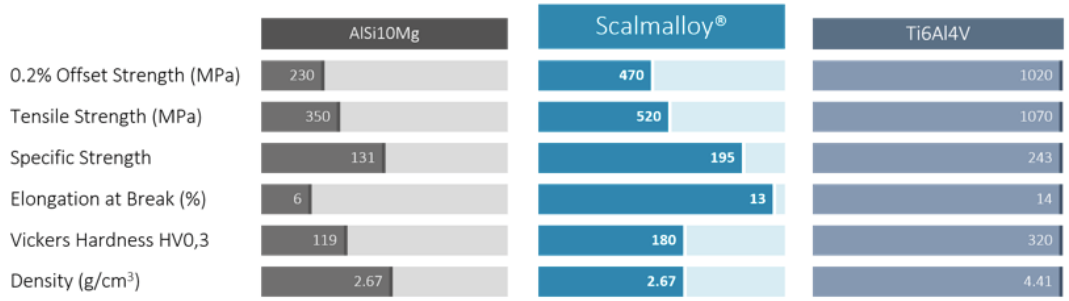
Scandium strengthens aluminium in three different ways: grain refining, precipitation hardening, and inhibiting recrystallization, or grain growth. Due to its fine grain refinement, scandium alloys reduce hot cracking in welds, increase strength in the welds and deliver better fatigue behavior. Welding filler/ thread with scandium has great potential for aluminium. Scandium increases the recrystallization temperature of aluminium alloys to above 600°C, well above the temperature range of heat treatable aluminium alloys.

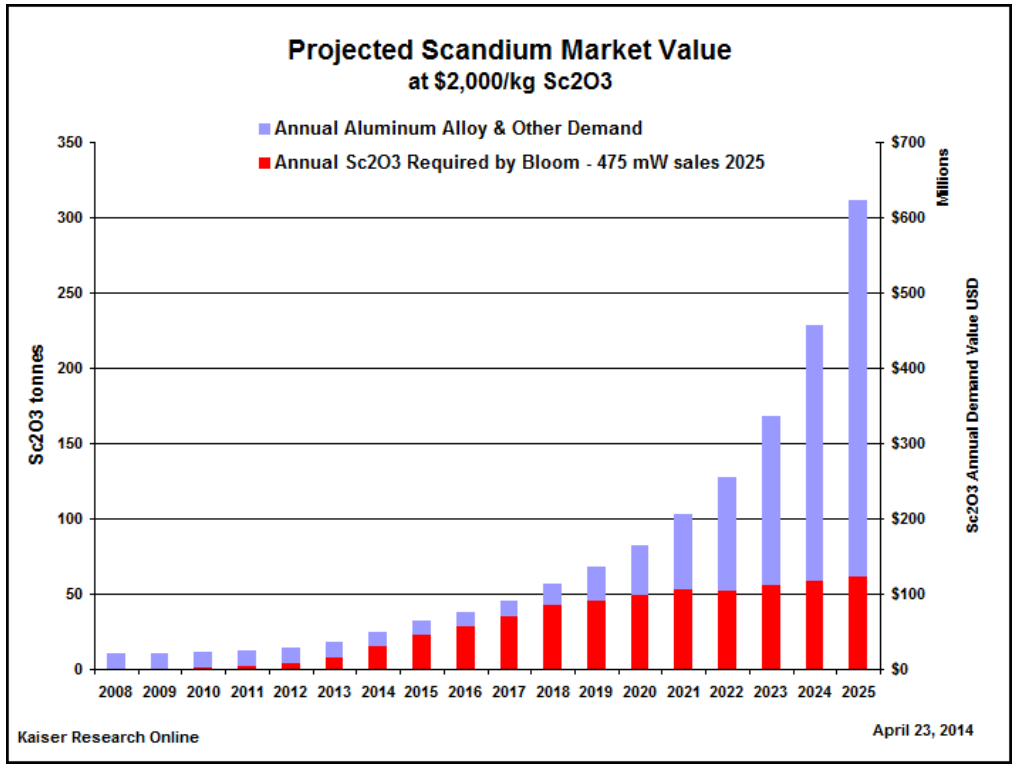


LEVERAGING EMERGING TECHNOLOGY SUPER ALLOY COUPLED WITH PATENTED ULTRASOUND ASSISTED EXTRACTIONTECHNOLOGY

Airbus Group APWorks GmbH, Germany, in cooperation with Airbus Group R&D, has developed Scalmalloy, a high-performance scandium-aluminium magnesium powder metal alloy designed for additive manufacturing of high-strength aerospace structures. Scalmalloy has exceptional high-fatigue properties with specific strength approaching that of titanium. In comparison, the AlSi10Mg aluminum silicon powder, widely used for additive manufacture, is only half as strong. It is stated that using aluminium-scandium alloys could reduce the weight of a large aircraft by 10%-15%.

Owing to its scarcity and limited production, scandium is one of the most expensive metals in the world. Prices for 99.99% pure scandium (RE: 99% min. l Sc/TREM: 99.99% min.) have fluctuated between US$4000 and US$20,000 per kilogram over the past decade, according to Strategic-metal.com. Due to the limited amount of material produced globally and the limited market for scandium, there is also a wide range of prices offered for the metal at any given time. A recent offer for 99.9% scandium concentrate was at US$15,000 /kg.The more widely used form in commercial applications, scandium oxide (Sc_2O_3), was recently offered at prices of around US$7000/kg, which is in the range of 20-year average. Depending on the percentage of the scandium alloying element, the price of the Al-Sc alloys are expected to cost between 30% more than non-scandium alloy (at scandium levels of between 0.06 up to 0.12 wt% as used in Al-Zn-Mg (Cu) alloys), and 100%.





VANADIUM CRITICAL TO INFRASTRUCTURE AND AEROSPACE

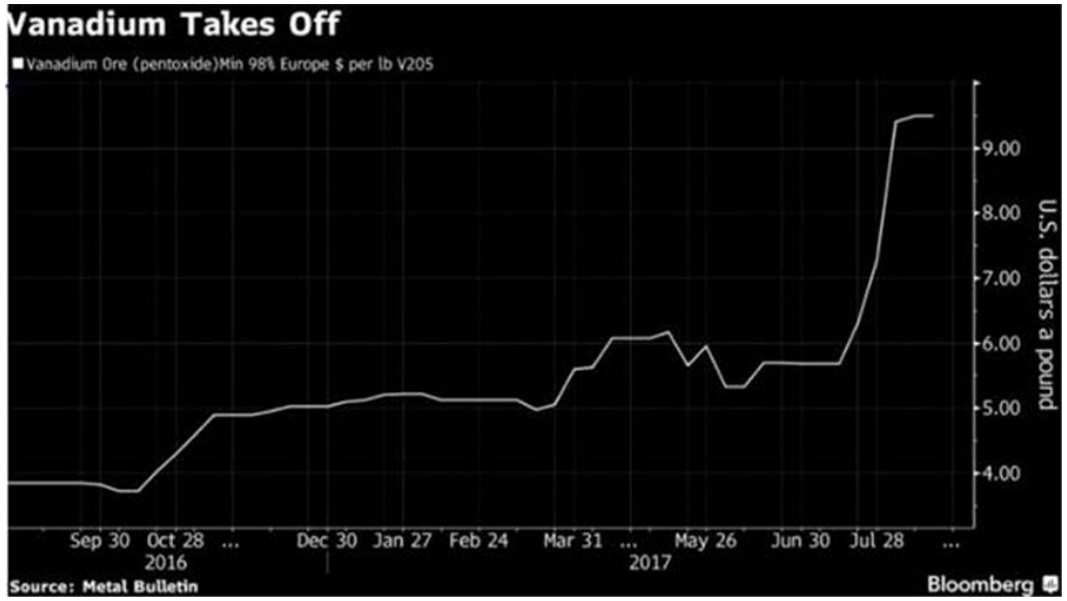
CRUCIAL STEEL ALLOY FOR AUTOMOBILE, AEROSPACE, INFRASTRUCTURE AND CRITICAL TO REDOX FLOW BATTERIES CAN BE DISCHARGED AND RECHARGED 20,000 TIMES WITHOUT MUCH LOSS OF PERFORMANCE AND LAST DECADES

Adding in as little as 0.15% vanadium creates an exceptionally strong and resilient steel alloy. It was found that in AlMgSuCu alloys with vanadium clearly relies Rm and Rp0,2, the additive vanadium in an amount of 0.2 wt.%. increases elongation almost doubled. Just two pounds of vanadium added to a tonne of steel doubles its strength, so it is unsurprising that 80% of vanadium is used to make ferrovanadium – a steel additive.

By 2025, it's estimated that 85% of all automobiles will incorporate vanadium alloy to reduce their weight, thereby increasing their fuel efficiency to conform to stringent fuel economy standards set by the US EPA. Vanadium's corrosion-resistant properties make it ideal for tubes and pipes manufactured to carry chemicals. Vanadium-titanium alloys have the best strength-to-weight ratio of any engineered material on earth. Less than one percent of vanadium and as little chromium makes steel shock and vibration resistant. A thin layer of vanadium is used to bond titanium to steel, making it ideal for aerospace applications. Mixing titanium with vanadium and iron strengthens and adds durability to turbines that spin up to 70,000 rpm. While V2O5 currently sells for between US$16,000 and US$17,000 a ton, titanium goes for just $US1,500 a ton, which means a low grade of titanium is an attractive feature of a vanadium prospect.

The latest estimate is that vanadium demand and supply currently intersect at about 80,000 tonnes per year. Market research firm Roskill predicts that by 2020 there will be about a 45% increase in the demand for vanadium, driven mostly by China. As an example of how much steel will be required to build just one new Chinese city – Xiong'an, consider that the city will likely need 20 to 30 million tonnes of steel, which translates to 30,000 tonnes of vanadium – roughly a third of current annual production, albeit over 10 years.

THE UNITED STATES AND CANADA, ARE COMPLETELY DEPENDENT ON RECYCLING (MOSTLY THROUGH RECOVERY FROM SPENT CATALYST FROM OIL REFINING OPERATIONS) AND IMPORTS FOR 100% OF THEIR VANADIUM SUPPLY



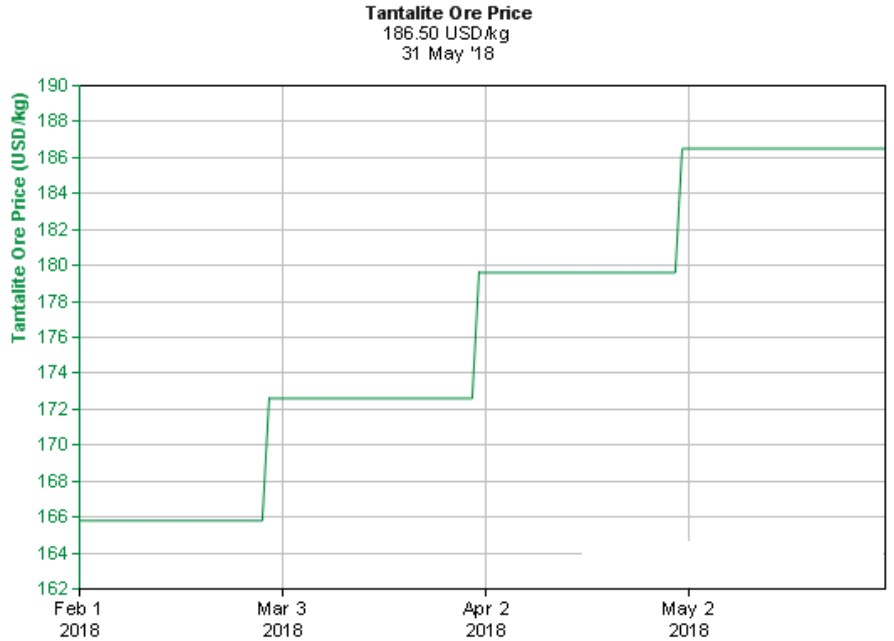
AUXICO RESOURCES

COLTAN SEPARATING THE UNIVERSALLY USED METAL FROM CONFLICT

COLTAN: NIOBIUM AND TANTALUM—INDISPENSABLE TWINS – USUALLY DIFFICULT TO SEPARATE IF NOT FOR PATENTED ULTRASOUND ASSISTED EXTRACTION TECHNOLOGY

The tantalite market has experienced significant price rises in the last two years, from just over USD 120/kg to over USD 186/kg. The market for niobium has remained relatively stable the past two years at over USD 42,000 per metric ton. COLTAN usually a conflict mineral, the 21st century blood diamond, can now be mined and processing through CAN Inc. strategic partnerships, avoiding the humanitarian concerns otherwise related with to these metals. "Coltan" is another name for columbite-tantalite, an ore containing a mix of niobium and tantalum. The value of tantalum consumed in the US in 2017 was estimated to exceed $240 million as measured by the value of imports. U.S. tantalum apparent consumption in 2017 was estimated to have increased 44% from that of 2016. U.S. imports for consumption increased 22% from those of 2016. The increase was largely attributed to the increase in imports of tantalum powders (30% increase) and tantalum waste and scrap (23% increase). Major end-use distribution of reported niobium consumption was as follows: steels, about 76%, and superalloys, about 24%. In 2017, the estimated value of niobium consumption was $290 million, as measured by the value of imports.

THE GLOBAL TANTALUM MARKET IS EXPECTED TO WITNESS A CAGR OF APPROXIMATELY 3.1%, DURING THE FORECAST PERIOD OF 2018 TO 2023, MOSTLY DRIVEN BY ITS INCREASING APPLICATION BASE IN THE ELECTRONICS INDUSTRY. THE EUROPEAN COMMISSION HAS PLACED BOTH NIOBIUM AND TANTALUM ON ITS 2017 LIST OF CRITICAL RAW MATERIALS FOR THE EU.



COLTAN: NIOBIUM AND TANTALUM—INDISPENSABLE TWINS – USUALLY DIFFICULT TO SEPARATE IF NOT FOR PATENTED ULTRASOUND ASSISTED EXTRACTIONTECHNOLOGY

Tantalum is increasingly important in the 21st Century, because it plays a large role in making personal electronic devices smaller, and it naturally fights corrosion. Tantalum capacitors have an extremely high capacitance packed in a small volume — perfect for shrinking our electronic devices, or making additional room in them for larger processors or speakers. Tantalum is also used to create surface acoustic wave filters, devices used in cell phones and televisions to improve audio quality. The average cell phone has about 40 milligrams of tantalum inside — not a considerable amount, but one that adds up quickly thanks to the millions and millions of cell phones in use. Tantalum capacitors experience an extremely low failure rate, making them perfect for use in medical equipment, including hearing aids and devices that you don't want to randomly fail, like pacemakers. Tantalum is not harmed by bodily fluids, and does not irritate the flesh of the implant knee, making it a perfect metal from which to create hip, knee, and other orthopedic implants.

Tantalum is rarely found in its elemental form — the element is often found with niobium and the radioactive elements thorium and uranium, and industrial processes are required to extract pure tantalum. Increased use of tantalum in electronic devices has increased the cost of capacitor-grade tantalum over the past decade, with the refined form currently hovering around $300 a pound, while lower grade forms routinely sell for $100+ a pound. The steel industry uses nearly 80 percent of the world's produced niobium to manufacture high- strength low-alloy steels. Niobium, a grain refiner and precipitation hardener, enhances the steels' mechanical strength, toughness, high-temperature strength, and corrosion resistance for use in pipelines, transportation, and structural applications. Appreciable amounts (>20 percent) of niobium are used in nickel-, cobalt-, and iron-based super alloys for high-temperature applications in jet engines, gas turbines, rocket subassemblies, turbocharger systems, and combustion equipment. In 2000, the ore typically sold on world markets for approximately $330.00 USD per kilogram.

RECENT TECHNOLOGY BOOM AND LOW AVAILABILITY OF COLTAN CAUSED A SUBSTANTIAL INCREASE IN THE PRICE TO ALMOST $400 USD PER KILOGRAM AT ONE POINT, AS SUPPLY STRUGGLED TO MEET THE DEMANDS OF COMPANIES SUCH AS NOKIA AND SONY.