Michael S. (Mickey) Fulp
M.Sc., C.P.G.

MercenaryGeologist.com
contact@mercenarygeologist.com

What Makes a Critical Metal "Critical" or a Strategic Element "Strategic"?

A Monday Morning Musing from Mickey the Mercenary Geologist

Contact@MercenaryGeologist.com

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I was a keynote speaker at the recent **Murdock Capital Partners Critical Metals / Strategic Elements Symposium in New York City**. This is my second gig at one of convener Tom Dean's on-going series of symposia and I thank him for continuing support. Although the venue is small, intimate, and limited to 75 attendees, the investor quality is second to none, particularly in the amount of money represented and managed. In my presentation I categorized the metals critical to modern-day civilization and reviewed the minor metals that are increasingly used by society in new technological applications.

Recently a plethora of alternative names have been proposed and promoted for what were once known as the specialty or minor metals. These mostly obscure elements span the gamut from the lightest to the heaviest on the periodic table. In my opinion, analysts and investors alike have become confused by these newly-invented misnomers.

Much of the confusion can be blamed squarely on two recent reports from the United States government.

In December 2010, the US Department of Energy (DOE) produced a report entitled "Critical Metals Strategy". It identified seven rare earth elements and three minor metals (lithium, indium, and tellurium) that are or could become in high demand and short supply from 2011-2025. The DOE list and analysis was predicated on future growth fueled by Obama's proposed subsidies of the electric and hybrid vehicle, wind turbine, solar, and fluorescent lighting industries.

Subsequently, the US Department of Homeland Security produced its list of "Strategic Metals" based on national and economic security and public health and safety. However, its list had few metals in common with the DOE compendium. Homeland Security's strategic metals were more realistic and included ferrous alloys chromium, manganese, titanium, and cobalt, and minor metals germanium, niobium, tellurium, the rare earth elements, and tungsten.

Not surprisingly, these government studies recommended bureaucratic and regulatory solutions involving interagency coordination, cooperative studies, research funding, comprehensive plans, and international workshops.

The various proposed names for the low demand metals are arranged below from youngest to oldest and include short explanations of their origins:

- Critical metals: DOE's aforementioned list in late 2010 is based on Obama's agenda for green energy subsidies.

- Electric metals: This is the title of annual conferences beginning in April 2010 and held by Byron Capital, a group of Toronto-based research analysts.

- Doping agents: A name that was proposed by The Hague Center for Strategic Studies in early 2010 for metals that are minor additives in alloys and composites.

- Rare metals: Don Bubar, CEO of Avalon Ventures, renamed the exploration company Avalon *Rare Metals* upon gaining a TSX listing in mid-2009.

- Technology metals: According to my source, this term was coined by materials engineer Jack Lifton and first used publicly in September 2007.

- Strategic metals: A term that was first used for both major and minor metals during the Department of the Army metal mining subsidies in the 1940s and 1950s. It also references the National Defense Stockpile from post-WWII until the Soviet Union's failure in the early 1990s.

However, this alphabet soup of metals has long been known by two names that are of common usage and are easily categorized by several key criteria: Specialty metals, which is the term I prefer; or if you wish, minor metals.

Before we delve further into the specialty metals, I offer my real world answers to the question, "*What makes a critical metal "critical"?*

In my opinion, the general characteristics of a critical metal include the following: It is essential to modern-day industrial processes and/or applications and therefore, world economic health and well-being; a major tonnage (with few exceptions greater than one million tonnes) is mined, processed, and used per year; it trades on open world markets, including futures and options; *or*, it trades as a bulk dry commodity via a negotiated contract or pre-set price.

I submit that these are the world's *critical* metals, arranged for the most part in order of their yearly mined tonnages:

- Iron ore (Fe) comprises 95% of the world's total metal production. Iron and steel are the foundations of our modern-day civilization and the Iron Age marked a major advancement for mankind beginning in 1200 B.C.

- Aluminum (Al) is the strong and lightweight metal that was not used in any major industrial application until the 1890s and now is the world's second most important metal with over 44 million tonnes of production in 2011.

- Copper (Cu) with a Ph.D. in Economics is the true "electric" metal. Its 19 million tonne supply, demand, and price most directly reflect the world's current industrial and economic health.

- The major ferrous alloys including: Chromium (Cr), the third most used metal at 24 million tonnes, manganese (Mn), fifth at over 14 million tonnes, nickel (Ni) with 1.8 million tonnes, and molybdenum (Mo) with 250,000 tonnes. These metals are alloyed with iron for various types and grades of steel, essential for today's industrial applications.

- Titanium (Ti) oxide production was 6.7 million tonnes in 2011. Titanium minerals are used mainly in the pigment industry in addition to 186,000 tonnes of metal sponge demand for iron and specialty alloys.

- Zinc (Zn, 12.7 million tonnes, lead (Pb, 4.5 million tonnes), and tin (Sn, 250,000 tonnes) are essential for major industrial applications including galvanizing, batteries, and alloys respectively. Copper-tin combinations were the first alloys used by Man and ushered in the Bronze Age at about 3300 B.C.

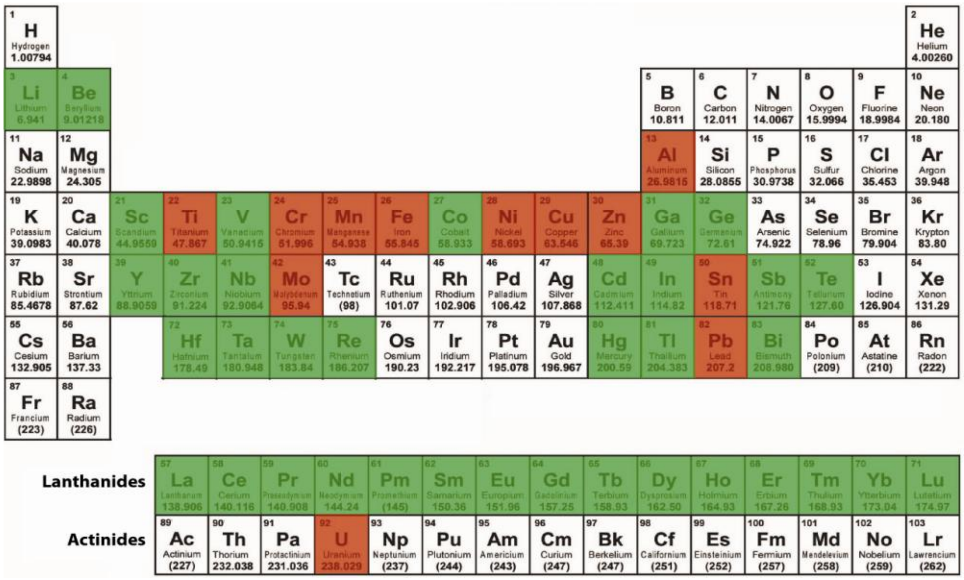
- Uranium (U) had no significant use or supply until the1950s but it now contributes 14% of the world's electrical energy supply. Current mine production of 53,000 tonnes is about 75-80% of annual world demand. Uranium diverges from the other critical metals in its relatively low tonnage and it does not trade on open markets, but it is no doubt essential for our long-term energy future.

Despite the aforementioned efforts to invent new names for the specialty metals, each individual metal has a number of common characteristics with its brethren. First and foremost, a specialty metal is non-essential to a healthy and well-functioning world economy.

It also has a small tonnage and a relatively small total value mined, processed, and used on a yearly basis; is a by-product or a co-product of large mining or smelting operations; *or*, deposits are small and the economics are especially sensitive to processing and refining costs.

In addition, a specialty metal does not trade on open markets and pricing is negotiated by buyers and sellers via term off-take contracts or spot sales. As a result, pricing, trades, supply movements, and annual production are largely opaque. World supply may be controlled by a monopoly or oligopoly via a company, deposit, country, or region.

This periodic table shows my categorization of the world's critical metals and specialty metals:



The Critical (Red) and Specialty (Green) Metals

Because I am a speculator in the junior resource sector, my on-going study of commodities is geared toward understanding supply and demand fundamentals and determining those metals that are suited as flagship projects for junior explorers or miners. With that in mind, I will provide a brief synopsis of each specialty metal and then reveal those that I currently consider permissive for successful speculation.

- Lithium (Li): The lithium compounds market is controlled by a cartel of three large chemical companies that extract the metal from shallow brines, mostly in South America. Lithium compounds are used mainly in batteries and grease. The spodumene market is monopolized by a single mine in Australia that supplies much of that mineral for glass and ceramics. China is also a major domestic supplier and consumer of both markets. Altogether, these sources produce an estimated 34,000 tonnes of elemental lithium in 2011.

- Beryllium (Be): The free world's beryllium supply of 240 tonnes is controlled by a US company in a mine-to-market monopoly supplied by a deposit in central Utah. Its production is supplemented with high-grade sorted ores from other countries used as mill sweeteners. Russia and China source beryllium from Soviet-era stockpiles in Kazakhstan as does a mid-tier US alloy fabricator. Beryllium is used in specialty alloys mostly for military and high tech applications.

- Scandium (Sc): World production is miniscule at an estimated two to four tonnes a year. It is a by-product of some REE mining and is also obtained from Russian stockpiles. Scandium is a minor component for specialty aluminum alloys used in aerospace applications and sporting equipment.

- Vanadium (V): It is produced mainly from steel mill slags, but also as a by-product of uranium mining and heavy oil residues with one stand-alone mine in South Africa. Current supply of 60,000 tonnes is sufficient to meet anticipated demand in iron alloys and catalysts. Recent speculation on increasing demand focuses on new battery applications.

- Cobalt (Co): The 98,000 tonne world supply is obtained as a by-product of nickel and copper smelting and is controlled by operations in central Africa and integrated mining companies elsewhere. Cobalt is used in high-strength superalloys, pigments, batteries, catalysts, and radioisotopes.

- Gallium (Ga): The world supply is a by-product of aluminum and zinc smelting and is controlled by giant aluminum and zinc companies that produced 216 tonnes in 2011. Gallium is used in semiconductors.

- Germanium (Ge): The 2011, 118 tonnes supply is a by-product of base metal smelting, mainly zinc, by the world's large base metal companies. Germanium is used in fiber optics, night vision devices, and catalysts.

- Zirconium (Zr): The world's supply of 1.41 million tonnes comes mainly as a by-product of titanium mining from heavy mineral beach sand deposits. Production is concentrated in Australia, South Africa, and the United States and generally controlled by major mining companies. Zirconium is used mainly in refractories and ceramics, but also in alloys, jewelry, and nuclear fuel assemblies.

- Niobium (Nb): About 75% of world supply of 63,000 tonnes comes from a single open-pit mine in Brazil that contains over 100 years of anticipated world demand. It produces at two to six times the grade of two other deposits of significance in Brazil and Canada. Ferroniobium and nickel-niobium are used as minor components of many specialty steels, and pure niobium is used in superalloy applications.

- Cadmium (Cd): Supply is a by-product of zinc smelting and controlled by integrated zinc companies; production was 21,500 tonnes in 2011. It is used mainly in batteries and to a lesser extent in electroplating applications. Cadmium is limited in its uses by toxicity.

- Indium (In): The 640 tonne supply is a by-product of base metal smelting by integrated mining companies with recycling contributing over half of annual world consumption. It is used mostly in thin film coatings for LCD, LED, and solar cells.

- Antimony (Sb): Most of the world's supply of 169,000 tonnes comes from China via mining and processing of small vein deposits. It is also recovered from smelting of some copper-silver ores. Antimony is used mainly in flame retardants and also in lead alloys for ammunition, batteries, and solder. Minor uses include electronics and pigments.

- Tellurium (Te): The world's supply of 115 tonnes is obtained from the refining of copper ores by integrated mining companies in the United States, Peru, Japan, and Canada. It is a minor additive to some iron, copper, and lead alloys, high-tech electronics, and solar panels.

- Hafnium (Hf): Zirconium ores always contain small amounts of hafnium. The world supply is obtained by separation from the pure zirconium required for cladding of nuclear fuel assemblies, a process that amounts to about 70 tonnes a year. Most hafnium is used in nuclear control rods; minor applications include specialty alloys and microprocessors.

- Tantalum (Ta): It generally occurs with niobium and the world supply of 790 tonnes comes from three mines in Australia and Brazil, as a by-product from processing of placer tin slags in

Malaysia, and artisanal placer mining in central Africa. Tantalum is used mainly for capacitors in personal electronic equipment with minor amounts used in specialty alloys.

- Tungsten (W): China currently supplies about 85% of demand from numerous small mines. Potentially economic deposits occur in many countries of the world. In 2011, about 72,000 tonnes were produced. It is used mainly as tungsten carbide and in steel and superalloys, with minor uses in electronics and as catalysts.

- Rhenium (Re): This metal is rare and expensive and does not form its own minerals. Supply of 49 tonnes is obtained as a by-product of molybdenum refining and is controlled by integrated mining companies. Rhenium is used in superalloys for jet and rocket engines and as a petroleum catalyst.

- Mercury (Hg): The world supply of 1900 tonnes is dominated by small mines in China with Kyrgyzstan also a significant producer. Mercury is used in industrial chemicals, electrical and electronic devices, and various lighting devices. It is also used by artisanal miners in many countries to recover gold, often with environmental consequences because of its toxicity.

- Thallium (Tl): Ten tonnes are recovered per year in the refining of base metal ores. Approximately 65% of thallium is used in electronics with the remainder in pharmaceuticals, glass manufacturing, and infrared detectors. It is extremely toxic and past uses are banned in many countries.

- Bismuth (Bi): The 8500 tonne supply is mostly obtained by refining of lead concentrates and other base metals and is dominated by China. Bismuth is used in pharmaceuticals, cosmetics, specialty alloys, solders, and as a non-toxic substitute for lead.

- Yttrium (Y) and the 15 Lanthanides (REEs): By-products from a large iron mine in China and a primary mine in the United States currently supply most of the world's light rare earth elements. Total rare earth supply in 2011 was 133,000 tonnes with yttrium oxide at 8900 tonnes. Yttrium and heavy rare earths come from small mines in southern China. New sources in North America, Australia, Europe, and Africa are undergoing development with initial production scheduled in four-five years. REEs are used in military, high tech, and green energy applications.

As can be seen from the list above, most of the specialty metals are not contained in concentrations that support stand-alone deposits. Many are by-products from the refining of major industrial metals while others are controlled by a monopoly or an oligopoly. Most have sources and supplies that are adequate for future world demand. Therefore, the majority of specialty metals are not well-suited as exploration targets for junior resource companies.

However, there is a justifiable concern about the dependency of the Western World on unfriendly and/or unstable sources for many of the specialty metals. As the Chinese economy continues to grow, its current specialty metals market is transitioning from export of products to domestic use. As this occurs, it is likely China will invoke additional incentives to keep mined supplies for internal consumption.

We saw this happen in 2009-2011 in the rare earth sector. The Chinese announced export taxes, tariffs, and quotas, metal prices skyrocketed, juniors companies piled in and on, and market capitalizations went exponential then parabolic. Although the REE bubble has largely run its course, there remain opportunities for a few select companies to compete successfully in the world marketplace. I was involved very early-on in the rare earth element sector and will always strive to duplicate that record with other specialty metals.

In my opinion, the specialty metals that offer attractive opportunities for speculation in the junior resource sector have three common characteristics: They occur in small monometallic deposits that can be developed with relatively low capital expenditures; they can be concentrated, processed, and a final product sold into a free marketplace without incurring significant third-party risk (i.e., no monopolies, cartels, or large smelters involved); and potentially economic deposits are located in countries that have acceptable geopolitical risk (i.e., stable and corruption-free governments, strong rule of law, mining-friendly, and reasonable bureaucratic and environmental regulations).

There are only a few metals that can ever match the criteria listed above. I currently consider antimony and tungsten to be top targets for juniors in specialty metal space and am searching for companies worthy of my speculative dollars. At this juncture I have found no obvious candidates, but rest assured my loyal subscribers will know soon after I take a position and initiate coverage.

To learn more about supply and demand fundamentals of the specialty metals, I invite you to listen to archived podcasts of my bi-weekly commodities program for Kitco Radio entitled: **Mercenary Musings Radio with Mickey Fulp and Rob Graham.**

Ciao for now,

Mickey Fulp
Mercenary Geologist

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The **Mercenary Geologist Michael S. "Mickey" Fulp** is a Certified Professional Geologist with a B.Sc. Earth Sciences with honor from the University of Tulsa, and M.Sc. Geology from the University of New Mexico. Mickey has 35 years experience as an exploration geologist searching for economic deposits of base and precious metals, industrial minerals, uranium, coal, oil and gas, and water in North and South America, Europe, and Asia.

Mickey worked for junior explorers, major mining companies, private companies, and investors as a consulting economic geologist for over 20 years, specializing in geological mapping, property evaluation, and business development. In addition to Mickey's professional credentials and experience, he is high-altitude proficient, and is bilingual in English and Spanish. From 2003 to 2006, he made four outcrop ore discoveries in Peru, Nevada, Chile, and British Columbia.

Mickey is well-known and highly respected throughout the mining and exploration community due to his ongoing work as an analyst, writer, and speaker.

Contact: **Contact@MercenaryGeologist.com**