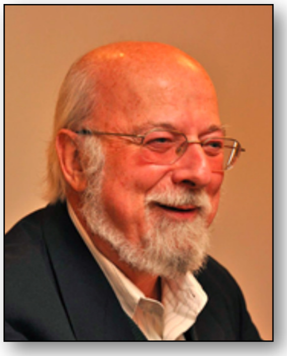
SPECIAL EDITION

THE JACK LIFTON REPORT

Rare Metals in the Age of Technology

By Jack Lifton – Founding Editor



DETROIT, Jan 9, 2010 - At the Essex House in Manhattan, NY last month, I delivered a presentation with the same title as this paper, to attendees of CLSA University, an ongoing executive education program produced by CLSA, one of Asia's leading independent brokerage and investment groups.

So, what are the rare metals, and why should we be concerned with their supply and their production rates? I want to clarify some terms by giving you some definitions along with the metric (i.e. the measuring method) I use to create them. First of all, I'm going to use the set of tables attached to this paper, to define a rare metal. I define a "rare metal" simply as one that is today produced at a yearly rate, less than the 2008 yearly rate at which lithium was produced. The second of the first three tables uses a dark line to separate two groups of metals. Those above the line I consider today to be the common metals; those below, I consider to be the rare metals.

My definition is not really arbitrary, nor is it time independent. 2008 was the year in which the production of most metals in particular and of all metals in total, reached the highest level in human history. A rare metal is not one that is simply scarce or not present above a certain percentage in the earth's crust - I have read both of these "definitions" in articles written by university faculty academics in peer reviewed journals. A rare metal, at any given time in history, is one whose sources are not *commonly* present in sufficient natural concentration, for its recovery, separation and concentration to processing-capable levels, using *available technology*, purification and fabrication into end use items, by practical and economical manufacturing techniques.

An easier way to grasp the above mouthful is to realize that in 1400 BC, iron was a rare and precious metal; in 1865 AD, aluminum was a rare and precious metal; and until 1945 uranium was a rare and almost useless metal.

This does not mean that ultimately all rare metals will become available in commercial quantities merely through improvements in our ability to process low grade (low concentration) ores. But it does mean that our ability to produce any metal is critically dependent on its being available in natural concentrations high enough to be processed economically, or that some other process that is economical, brings about access to a rare metal as a byproduct of our recovery of another metal.

It is, of course, true that there may be large bodies of high grade ores of many metals undiscovered as of yet, but, since the accessible face and reasonable depths of the earth's surface have been explored in most temperate climates, these deposits will be in places inaccessible due to depth, height, lack of roads and other necessary infrastructure or beneath the sea or the poles.

The human race does not conserve resources; it squanders them as if they were infinite, and they are not. No one is going to deploy all of the machinery and all of the energy available to mankind, to sift through cubic miles of the earth's crust in the hope of recovering a few tons of neodymium that are believed to be statistically likely to be present in any few million tons of the earth's crust. Yet that nonsense is the driver for many statements that metals such as neodymium are earth fundamental and are present at a higher concentration than lead in the earth's crust.

The colors of the text in some of the rows in the first set of three tables are indicative of the relationships between some of the key "common metals" and those of the "rare metals", which are almost only produced as byproducts from, and because of the large volume of production of, the common metals in which they are found as "traces". The fourth table shows four of the largest volume metals produced today and below each common metal are the byproducts which come to us in useful volumes only because, and only so long as, their "parent" metals are produced in large volumes. Our technological society is in fact now totally dependent on these byproduct metals. This fourth table also shows the rare earth elements and thorium, commonly found with the rare earths.

If you look at the tables closely you will see that relative to 2008 production levels, it is almost a surety that increases in production of any metal, common or rare, with one or two exceptions only, from now on will be marginal. This is a function primarily of the enormous investments that have been made in equipment, extraction and refining technology, operational infrastructure, and manpower to bring us to the present levels of production.

It is often said that 600 million of us now enjoy the fruits of our high technology civilization and that 6 billion are waiting in the wings to join the party. One problem with that hypothesis, is that *there is no way to bring the world's continuous annual production of the critical natural resources of metals (and energy) to an ongoing figure of 10 times that of 2008*, to supply the 6 billion the material goods with which we define our quality of life. If our society were foolish enough to attempt such a production increase or any significant part of it, we would exhaust our accessible reserves of ores at any conceivable workable level, long before we achieved more than a two or three times increase in production, and from then on the world would only be able to produce metals by recycling them at an enormous cost in energy.

We may have already reached the technical limits of our ability to recover even some common metals economically from low grade (low concentration) ores. Our society is today wasting many increasingly precious rare metals through dissipative uses i.e. uses in which the concentration of the desired metal in the scrap is so low that it is uneconomical to recover it through recycling. Talk of conservation and recycling of utilitarian rare metals, the *technology metals*, is mostly cocktail-party chatter in the rich West, but it is a necessary way of life in the East. This situation will end in the West as the organized competition among Asian nations for utilitarian rare metals ultimately ends the export of such metals produced or recycled in Asia, in favor of their use and conservation for domestic purposes.

I sincerely believe that the West is in its last generation of ease of access to rare metals not found within our national borders. This means that the continued waste of utilitarian rare metals for some frivolous technologies will simply end.

I have not addressed the world's reserves of metal ores of such concentration that they can be processed economically today, but even though at current production (2008) levels we may have enough iron ore, limestone, and coking coal to last for centuries **we do not have enough resources or reserves of many key technology metals to continue wasting them at the current rate** even if we only use them to maintain our Western standard of living and quality of life!

What is the Outlook for the Strategic and Critical Rare Metals for Technology?

A **strategic metal** can be defined, economically, as one that is necessary to, or important in, the start up, operation, or completion of a long term plan (i.e. a strategic plan) to mass produce or manufacture items, collectively or individually, which require large amounts of metal.

For example, the plan by a private business to construct an office building must consider the cost and availability of structural steel as a strategic necessity; this seems trivial at first glance, but it becomes very important when the strategic metals are or include even one rare **critical metal**, defined as one for which there is no substitute (in performance or economics) so that without it, the project cannot be implemented or continued without guaranteeing the security of the supply of the particular specific metal.

For example, advanced jet engines that burn less fuel and are more efficient usually operate at higher temperatures than the ones they replace; such engines all require alloys that use the extremely rare metal rhenium and the very rare metal yttrium. If the engine cannot be produced or sold without meeting specifications that can only be assured by making some of its components from rhenium and yttrium alloys, then without ensuring the security of supply of these two metals beforehand the project may, in reality, be too risky to even start. Yet until now, such considerations of insuring the security of supply have commonly been either overlooked or ignored.

This is because until the twenty-first century's global explosion of demand for high technology goods, procurement officials at private companies assumed that the market forces of price and demand would always combine to make supplies of all metals available competitively. It was commonly believed that these forces applied equally to all metals including the rare ones, which, like gold, it was assumed, would and could always be available, given enough time to accumulate them, in any desired quantity if one was willing to meet the market price. Thus *all metals* were viewed as commodity metals subject to and reacting in the same way to market forces.

Thus the rarity of a metal was assumed, if any thought was given to its procurement as a special project, to be caused by a production rate limitation; some metal ores were harder to find, but, given enough time and money, it was assumed, any metal could be obtained. This assumption is wrong; it is based on a fundamental misunderstanding by business and government economists of geology and mining and refining engineering.

In order to educate ourselves and understand the fundamental error we need to ask:

1. How metals are produced, which is to say, where do the metals we can use actually come from?
2. What quantities of new metals are produced each year, and can the production rates of any or all of them now be increased beyond 2008 levels, or can or will the production rates for some of them actually decrease?, and
3. How does the location of the production sites for any and all metals factor into their availability, if at all?

Q1: How are metals produced?

This is not a trivial question. In fact there are two and only two possible sources for the production of any metal.

First of all, and primarily, the metal can be mined from an accessible and large enough ore deposit of high enough grade (percentage of desired material in the whole) so that currently available technology can economically:

1. **Extract** the ore from the substrate, such as rock or sand, in which it is contained;
2. **Separate** the ore from the lower (or no) value materials in which it is embedded;
3. **Separate and refine** the natural chemical compound, which make up the "ores," into individual metals, or individual metallic compounds;
4. **Purify** the metals or compounds to whatever degree of quality is desired;
5. **Fabricate** the metals into useful physical, metallurgical, or chemical forms, and
6. **Manufacture** the devices and products which are dependent on the metals for their strength, shape, or purpose.

If any one of these steps is not possible or uneconomical then the metal will have no commercial use until such time as that step in the chain becomes economical.

Second, if a sufficient quantity of either the industrial scrap left over from the fabrication of the desired products, or if the end products themselves have a high enough content of the desired metals or metals, then the industrial process scrap or the worn out products may be inserted into the above enumerated processes at an appropriate place, and then processed until the metal once again has been through Step 5 above. At this point the metal is indistinguishable from the metal produced from ore and is said to have been "*recycled*."

Logic applied to the above metric tells us that mining exploration is always the first step; this process is commonly known as exploration and is a meticulous operation characterized as much by luck and "experience" as by geological knowledge. Exploration is mostly the provenance of "junior" miners defined as those who mostly explore for valuable minerals in the hope that they will be able to find and characterize deposits, whose intrinsic value will lead to their sale to larger mining companies that will develop and mine the minerals - a very, very expensive and time-consuming process.

Junior mining companies frequently announce "discoveries" of desirable minerals and metals and those discoveries most often are of small amounts of material, which the junior miner hopes will be the precursor of an accessible, minable, large, high-grade ore body.

Institutional investors normally are very conservative with regard to committing to the large investments necessary to bring an ore discovery into final production, which we will define as the completion of Step 3 above - this is usually as far as the "mine" goes. The main reasons for such reticence are the considerable sums necessary prior to any evaluation of the deposit just to see if the ore body is large enough and rich enough, so that if it is accessible, and the chemical processes exist or can be developed to recover the desired metals or minerals, the mine's final product can be sold at a profit at the end of Step 3 above. The volatility of commodity metal prices over the last century and a half, have made mining finance into a high risk game that is difficult to hedge against loss.

However a change has now occurred in the world of metals that is only now being perceived by institutional investors. The recent recession caused the commodity metals, which I call the structural metals, to drop precipitously in demand and price after nearly a decade of record increases in their production. Rare metals prices mimicked structural metals prices during most of the recession, but now the rare metals are described as "leading the recovery." Actually this is not entirely correct. What is happening is that the rare metals are in fact qualitatively different in their uses from the structural metals; they are the "technology metals," and the market for them is now standing on its own.

The main issue surrounding the supply of the rare metals that are the new strategic and critical metals of the age of technology, is that both their availability in nature and their rates of production and recycling are limited.

Institutional investors have up until now confused the economics of widely available structural metals with those of the technology metals. An increased demand for structural metals can and will cause an increase in their supply. Also price can and will drive supplies of structural metals to the highest bidder. These simple rules do not apply to the procurement of the technology metals, because the most important factor for them is their availability in large enough and rich enough ore bodies (or, as we will discuss, as byproducts of structural metals) to be produced economically at all. Even where such ore bodies occur, the rate of production (of any metal) is determined by its accessibility to logistics, water, and energy. Mines of any type also take a very long time to be brought into production.

The most common error made by institutional investors in assessing the net present value of a rare metal ore body, is the misconception that the relative amount of a metal in the earth's crust or in the ocean, is a measure of the availability and accessibility of that metal for use. The distribution of a metal in the earth's crust or ocean has absolutely nothing to do with its availability or accessibility. Both of these issues are measured only by the availability and accessibility of large high grade deposits of the ores of these metals, in regions of the earth where the infrastructure of logistics, electricity, water, and labor are economically available. When any or all of these elements of the infrastructure have to be created in order to mine the metal. the cost of the creation of this infrastructure, when amortized and placed as a liability of the mine, must still result in a selling price for the metal that is competitive. Of course for a critical metal for the military or for health is involved the calculation of price may become secondary to availability.

Q2: What quantities of new metals are produced each year, and can the production rates of any or all of them be increased or will the production rates for some of them actually decrease?

The tables associated with this paper allow us to see the production rates of the most important common and rare metals for the last five years. Note well that even during the build up to 2008, the greatest production year (by volume) of all time, the buildup was not a smooth upward progression in all metals, by any means. If it were not for the enormous increase in the production of steel, and thus of iron ore, by China between 2004 and 2008, which accounted for more than 90% of the total increase in all metal production in that period, there would have been no record world production.

Just a note here about recycling: Our civilization has wasted many rare metals by either not simply recovering them when it would have been most economical and most practical, or by using them in dissipative ways, thus creating "grades" of scrap too poor in rare metals content, to be economically or even practically recoverable with current technology. The table above details the global production for 2008 of the most important metals of all types for our civilization; the totals represent the production rate achieved after a decade of the most available finance ever proffered to the global mining industry. Some of the resources and reserves of even the most common metals are now nearing the exhaustion of high grade (high percentage content of the desired metal) and new technologies for recovering them from lower grades must now be developed. Such recovery technology is time consuming, expensive, and frequently leads to dead-ends. Such "improved' technological development therefore cannot be predicted to simply just happen even over a long time frame.

Spaceship Earth has finite recoverable resources, and so the questions become, can we significantly increase the global production of new metal or are increases from now on going to be only marginal, if at all, and when, not if, will new metal production rates decline? There may be some quantitative errors in the tables above; but there are no qualitative errors. The production ratios of the listed metals are accurate. As an example of an extreme, the production of raw steel in 2008 was equal to one million pounds of raw steel for each one pound of zirconium produced! For each nine hundred thousand pounds of aluminum produced in 2008, less than 15 ounces of the metal critical for the manufacturing of efficient and high temperature operation jet and rocket engines, rhenium, was produced.

This waste cannot continue if there is to be widespread use of green technologies for producing and using energy without the burning of fossil fuels. There is no green path to the future without mining and using rare metals.

Q3. How does the location of the production sites for any and all metals factor into their availability, if at all?

For the US economy, currently the world's largest economy and, according to the National Mining Association, the location of the most diversified natural resource base of any country in the world, the reliance upon imports for 100% of strategic and critical natural resources, as calculated by the United States Geological Survey (USGS), had grown by the end of 2008 to more than 25 metals. This figure has tripled in the first decade of the twenty-first century, but the incredible part of this growing reliance by the USA on imported metals is that in almost every case, for each metal, the USA has accessible and available domestic resources of the metals upon which it has become resource reliant.

Unlike any other industrialized or industrializing country on earth the USA has stopped creating wealth, producing its own strategic and critical resources, even those required critically by its own military and non-fossil fuel energy producing and using industries!

China, Japan, Korea, and the European Union all have strategic stockpile programs in place to inventory a growing list of strategic and critical metals to safe guard their security of supply for both their civilian and military industries. The EU, for example, has identified 40 metals as being qualified to be considered strategic and critical for the economic preservation of its industrial base.

The USA has not amended its Defense Strategic Stockpile Act since 1979, and therefore the USA does not even consider any of the technology metals to be critical much less strategic.

It is only a matter of time before a general technology metals supply crisis erupts in the USA and the time during which the USA can become a participant in the global race to produce and stockpile strategic and critical metals both physically and through ownership and operation of their sources is running out.

Unless American bankers recognize that availability and production rate are just as important market drivers as demand and price, the US will soon fall behind permanently in its ability to support high technology industries and any green revolution will be dependent on imported natural resources and technologies. See the chart put out by the USGS listing the import reliance of the USA in 2008 for selected metals and minerals.

A great deal has been written in the last few months about China reducing its export allocation of the rare earths, of which it today is essentially the world's sole supplier. The global investment community has responded to China's determination to be self sufficient in supplying and developing its domestic high and green technology base, by running up the share prices of the few rare earth mines in development outside of China. Even now, as literally dozens of rare earth "discoveries" are turned into listings on stock exchanges, the investment community has begun to lose interest in the space, because it has determined that once again demand has increased supply. This is a huge mistake in judgment. The probability of success for 95% of the new ventures in rare earth metals in any reasonable time frame is zero; their deposits will turn out to be non-economical for a variety of technical, practical, and even some political reasons all of which are eminently foreseeable.

I call on institutional investors to underwrite the development of natural resources, by assigning a risk of future production factor to selected mining opportunities and securitizing off-take agreements negotiated with the best of the mines to be developed, so that such securities may be traded and priced to develop a basis for planning by industry and government for security of supply of the rare metals critical for the future of green technology.

I offer to assemble a committee of mining experts and economists to create a new metric for assigning risk to such securities, and to start the process with a study of the world's rare earth mining opportunities. I will be showing such a metric of my own design in 2010 via my web site, www.jackliftonreport.com.

There is no way to set the USA "On The Green Road" without secure access to the raw materials critical for green technologies to be manufactured in such quantities so as to be pervasive, and there is no hope for the world to be set firmly on the path to a green future, without a prior global approach to the production and conservation of the rare metals.

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About the Author: Jack Lifton is an independent consultant, prolific author and popular speaker who specializes in the market fundamentals and end use trends of rare metals. His work covers exploration and mining, separation and refining, and recovery of rare metal values by the recycling of not only rare metals and their alloys but also of metal-based chemicals used as raw materials for component manufacturing.

Mr. Lifton has more than 47 years of experience in the global OEM automotive, heavy equipment, electrical & electronic, mining, smelting & refining industries. Today he primarily consults to institutional investors doing due diligence on metals related opportunities. He can be emailed via jack@jackliftonreport.com.

Annual Global Production of New Metal

THE JACK LIFTON REPORT

Data Retrieved from USGS 12/11/09

Metal	New mine production (metric tons)								
	2004	**2005**	**Δ (%)**	**2006**	**Δ (%)**	**2007**	**Δ (%)**	**2008**	**Δ (%)**
Iron Ore	1,350,000,000	1,520,000,000	12.6	1,690,000,000	11.2	2,000,000,000	18.3	2,200,000,000	10.0
Raw Steel	1,050,000,000	1,130,000,000	7.6	1,170,000,000	3.5	1,340,000,000	14.5	1,360,000,000	1.5
Pig Iron	712,000,000	825,000,000	15.9	865,000,000	4.8	947,000,000	9.5	958,000,000	1.2
Aluminum	29,800,000	31,900,000	7.0	33,100,000	3.8	38,000,000	14.8	39,700,000	4.5
Copper	14,600,000	15,000,000	2.7	15,100,000	0.7	15,400,000	2.0	15,700,000	1.9
Manganese	9,900,000	11,000,000	11.1	12,200,000	10.9	12,600,000	3.3	14,000,000	11.1
Zinc	9,600,000	9,930,000	3.4	10,300,000	3.7	10,900,000	5.8	11,300,000	3.7
Chromium	17,500,000	19,600,000	12.0	20,000,000	2.0	21,500,000	7.5	21,500,000	0.0
Boron	4,960,000	4,840,000	-2.4	3,580,000	-26.0	3,840,000	7.3	4,100,000	6.8
Lead	3,200,000	3,520,000	10.0	3,650,000	3.7	3,770,000	3.3	3,800,000	0.8
Nickel	1,360,000	1,460,000	7.4	1,560,000	6.8	1,660,000	6.4	1,610,000	-3.0
Magnesium	595,000	622,000	4.5	675,000	8.5	775,000	14.8	671,000	-13.4
Strontium	470,000	494,000	5.1	550,000	11.3	511,000	-7.1	512,000	0.2
Tin	304,000	305,000	0.3	296,000	-3.0	326,000	10.1	333,000	2.1

Annual Global Production of New Metal

	New mine production (metric tons)								
Metal	**2004**	**2005**	**Δ (%)**	**2006**	**Δ (%)**	**2007**	**Δ (%)**	**2008**	**Δ (%)**
Molybdenum	159,000	186,000	17.0	187,000	0.5	209,000	11.8	212,000	1.4
Antimony	142,000	171,000	20.4	173,000	1.2	170,000	-1.7	165,000	-2.9
Lanthanides*	102,000	122,000	19.6	137,000	12.3	124,000	-9.5	124,000	0.0
Cobalt	52,900	58,600	10.8	63,400	8.2	65,500	3.3	71,800	9.6
Vanadium	51,900	56,400	8.7	57,900	2.7	59,100	2.1	60,000	1.5
Niobium	41,900	60,300	43.9	51,200	-15.1	60,400	18.0	60,000	-0.7
Tungsten	66,600	59,600	-10.5	56,600	-5.0	54,500	-3.7	54,600	0.2
Uranium						41,279			
Lithium	18,400	21,500	16.8	24,400	13.5	25,800	5.7	27,400	6.2
Silver	19,900	20,800	4.5	20,400	-1.9	21,100	3.4	20,900	-0.9
Cadmium	18,600	20,100	8.1	19,900	-1.0	19,400	-2.5	19,600	1.0
Yttrium	2,400	6,080	153.3	8,900	46.4	8,900	0.0	8,900	0.0
Bismuth	5,600	5,400	-3.6	5,800	7.4	6,200	6.9	7,700	24.2
Gold	2,420	2,480	2.5	2,370	-4.4	2,340	-1.3	2,330	-0.4
Selenium	1,440	1,340	-6.9	1,440	7.5	1,540	6.9	1,590	3.2
Zirconium	850	1,180	38.8	1,180	0.0	1,430	21.2	1,360	-4.9
Tantalum	1,520	1,470	-3.3	964	-34.4	815	-15.5	815	0.0
Indium	392	493	25.8	578	17.2	553	-4.3	568	2.7

* 15 metals

Annual Global Production of New Metal

	New mine production (metric tons)								
Metal	**2004**	**2005**	**Δ (%)**	**2006**	**Δ (%)**	**2007**	**Δ (%)**	**2008**	**Δ (%)**
Platinum	200	211	5.5	216	2.4	213	-1.4	200	-6.1
Palladium	211	216	2.4	222	2.8	219	-1.4	200	-8.7
Germanium	87	90	3.4	90	0.0	100	11.1	105	5.0
Gallium	69	69	0.0	69	0.0	80	15.9	95	18.8
Rhenium	42	49	16.7	47	-4.1	51	8.5	57	11.8
Rhodium	30	30	0.0	30	0.0	30	0.0	30	0.0
Hafnium	17	22	29.4	22	0.0	26	18.2	25	-3.8
Tellurium	UNKNOWN	UNKNOWN		UNKNOWN		UNKNOWN		UNKNOWN	
Scandium	UNKNOWN	UNKNOWN		UNKNOWN		UNKNOWN		UNKNOWN	
Thorium	UNKNOWN	UNKNOWN		UNKNOWN		UNKNOWN		UNKNOWN	

Annual Global Production of New Metal

Metal	New mine production (metric tons)								
	2004	**2005**	**Δ (%)**	**2006**	**Δ (%)**	**2007**	**Δ (%)**	**2008**	**Δ (%)**
Aluminum	29,800,000	31,900,000	7.0	33,100,000	3.8	38,000,000	14.8	39,700,000	4.5
Gallium	69	69	0.0	69	0.0	80	15.9	95	18.8
Zinc	9,600,000	9,930,000	3.4	10,300,000	3.7	10,900,000	5.8	11,300,000	3.7
Cadmium	18,600	20,100	8.1	19,900	-1.0	19,400	-2.5	19,600	1.0
Indium	392	493	25.8	578	17.2	553	-4.3	568	2.7
Germanium	87	90	3.4	90	0.0	100	11.1	105	5.0
Lead	3,200,000	3,520,000	10.0	3,650,000	3.7	3,770,000	3.3	3,800,000	0.8
Tungsten	66,600	59,600	-10.5	56,600	-5.0	54,500	-3.7	54,600	0.2
Bismuth	5,600	5,400	-3.6	5,800	7.4	6,200	6.9	7,700	24.2
Molybdenum	159,000	186,000	17.0	187,000	0.5	209,000	11.8	212,000	1.4
Selenium	1,440	1,340	-6.9	1,440	7.5	1,540	6.9	1,590	3.2
Rhenium	42	49	16.7	47	-4.1	51	8.5	57	11.8
Tellurium	UNKNOWN	UNKNOWN		UNKNOWN		UNKNOWN		UNKNOWN	
Lanthanides*	102,000	122,000	19.6	137,000	12.3	124,000	-9.5	124,000	0.0
Yttrium	2,400	6,080	153.3	8,900	46.4	8,900	0.0	8,900	0.0
Scandium	UNKNOWN	UNKNOWN		UNKNOWN		UNKNOWN		UNKNOWN	
Thorium	UNKNOWN	UNKNOWN		UNKNOWN		UNKNOWN		UNKNOWN	