General Motors engages with MP and Germany's Vakuumschmelze for Rare Earth Permanent Magnets

General Motors (NYSE: GM), has announced supplier agreements with both U.S. Based, MP Materials Corp. (NYSE: MP), and with Germany's Vacuumschmelze (VAC). This is very significant news, I think, because it means that GM will engage to support (financially, most likely,) Germany's Vacuumschmelze to enter the U.S. market and to expand its existing sintered rare earth permanent magnet (REPM) production by adding (unspecified) capacity in the USA. It's unlikely that VAC will drop any German (EU) customers, so to supply GM, it will add U.S. capacity. VAC says that it will add that capacity and begin U.S. production of REPMs for GM by 2024. America's MP Materials is also to be engaged by GM as a REPM supplier, and I suspect, as a future supplier to VAC of NdPr metal as raw material for VAC domestic American REPM production for GM. The UK's Less Common Metals (LCM) is the only non-Chinese (perhaps also non-Japanese) supplier to VAC of rare earth metals now, but LCM can only produce 120 tpa of Nd metal at this time, and thus can support only 400 tpa of domestically produced (in the UK or EU) REPMs of the sintered Neodymium-iron-boron (NdFeB) type. LCM's customer is VAC, whose customer for REPMs is most likely Daimler, for its (Daimler's) in house electric motor production (in Germany now but to be expanded to the UK).

I think it very likely that Daimler is supporting VAC to also expand its capacity, in Europe, for its needs for sintered REPMs of the NdFeB type. Daimler and VAC also need to find additional Nd metal supplies for VAC in Europe. I won't be surprised if LCM is bought by Daimler or financed by Daimler to expand its rare earth metals production capacity.

No OEM car maker wants to single-source a critical production part, so that this announcement doesn't mean that GM is going to rely on just VAC or MP Materials for REPMs. It's not unusual that GM will support MP Materials also at the same time as VAC to ensure that it has a principal supplier and at least one second source. This has long been the automotive industry's standard sourcing procedure. In this case, the experienced and existing VAC is to be the principal supplier, and MP Materials will be a second source.

I suspect additional future suppliers of REPMs chosen by GM are undergoing due diligence right now.

VAC is really the Western World's (outside of Japan) largest, perhaps only, OEM of REPMs for automotive production use. It is thus the only choice currently for a non-Chinese Western OEM automaker who wants "domestic" REPMs. But its capacity, currently only in Europe, is probably sold out to EU-based OEMs. This is the reason that to expand into the domestic American market it needs to add capacity, and this is the reason that GM is "supporting" VAC in building an REPM plant in the USA dedicated to the supply of GM. Magnet makers can only make magnets if they have secure supplies of raw materials, at competitive prices, and dedicated customers who will pay for finished goods by an indexed (to raw material costs) price. This is NOT the traditional pricing agenda in the OEM automotive industry. Fixed prices over the life of the contract are standard, and, in fact, the wild ride of neodymium prices in the last year has made REPM manufacturing for the OEM automotive parts industry a nightmare for those with the traditional fixed-price-for-the-life-of-the-contracts with OEM automotive. It's very unlikely that VAC would commit to building a (just-in-time[?]) U.S. plant for a customer without financial assistance and guarantees and an indexed price. I hope that both GM and VAC will let us know if GM has "broken" protocol. This will have a lot to do with achieving any government subsidies for domestic REPM manufacturing.

Now for the bad news. A typical GM EV using the Ultium(TM) platform power train (a lithium-ion battery and an electric motor), if it uses a REPM based motor (REPMM) will need between 2.5 and 5 kg of NdFeB magnets. A 1000 tpa REPM facility can thus supply the needs for REPMMs of between 200,000 and 400,000 new cars. GM has consistently been making about 3,000,000 cars and trucks per year in the USA (forget 2020. It's an outlier). So, to convert its domestic production to EVs entirely GM would need a maximum of 10,000 tpa of sintered NdFeB, REPMs. There is today no domestic REPM production capacity in North America. It will take a long time, if it even ever can be done, to achieve such a REPM capacity in the USA. But even if it is possible, it would only be possible with guaranteed pricing for the feedstock raw materials (separated rare earths, rare earth metals, and magnet alloys), and a guaranteed competitive REPM price for a break-even capacity.) This is not just a monumental supply chain cost management problem; it is a complete break with legacy OEM Automotive sourcing cost structure management, because it makes REPM and REPMM costs unpredictable!

In my opinion, GM is not solving the domestic REPM supply chain problem; it is addressing it, rather than just talking about it as politicians are wont to do. GM is putting its money where its mouth is.

But, GM is not the only OEM car maker that produces or sells products into North America's nearly 20 million unit per year market. Total conversion of that market to EVs that use REPMMs would need 60,000+ tpa of REPMs annually. Europe's car market is larger than North America's, and China's domestic market is larger than Europe's. Today, China alone has the existing capacity in REPMs, REPMMs, and Lithium to transform its domestic car market production entirely to EVs, and it has announced that it will reach 20% of that goal by 2025 and 40% by 2030.

Projections of near-term EV production proportions for the

American and European markets are wildly unrealistic, just based on the necessary critical raw materials and components capacity needed to achieve those goals. The build-out of the non-Chinese EV industry is just beginning in the West, and I think a long steep, very expensive, learning curve is ahead of us. I'm going to begin to address the critical raw material dilemma for EVs next week.

One of the world's richest rare earth deposits continues towards resolution of issues with Burundi partner

Rainbow Rare Earths' production in Africa to be expanded through extraction from South African mine tailings.

When it comes to rare earths it is important to identify the most valuable ones. Rare Earth permanent magnet production accounted for 91% of the total monetary value of rare earth consumption in 2019, and neodymium and praseodymium (NdPr) are the two key rare earth elements used in permanent magnets, particularly neodymium. This explains why most rare earth miners target NdPr. They are simply the most in demand and are highly valuable.

Rainbow Rare Earths Limited (LON: RBW) ("Rainbow") is a rare earths miner targeting NdPr production at their two African rare earth projects. Rainbow's strategy is to become a

globally significant producer of magnet rare earths. Rainbow has two African-sited projects, each of which has a special attribute leading to potentially lower cost mining. Rainbow also has exclusive rights, across the SADC region of Africa, to privately owned American specialty chemical engineering company's (K–Tech) rare earths continuous ion chromatography separation technology. The K-Tech process targets individual separation of rare earth from natural mixtures in fewer stages with more flexibility than traditionally used solvent extraction thereby saving on upfront CapEx and ongoing OpEx and potentially producing a higher end-value separated oxide rather than a carbonate. Testing is ongoing.

Rainbow's two rare earths projects are:

- The Phalaborwa Project in South Africa.
- The Gakara Project in Burundi, East Africa.

The Phalaborwa Project (70% earn-in agreement)

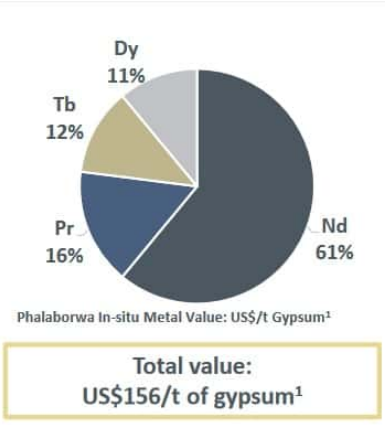
The Phalaborwa Project comprises an Inferred Mineral Resource estimate of 38.3Mt at 0.43% Total Rare Earth Oxides (TREO) contained within gypsum 'tailings' stacked in unconsolidated dumps derived from historic phosphate fertilizer hard rock mining. Being a tailings resource eliminates the need for hard rock mining, which is expected to lead to lower operational costs. The Resource has a high-value NdPr content representing 29.1% of the total contained rare earths, measured as oxides, with economic dysprosium and terbium, key rare earths for high temperature operation of permanent magnets, as valuable by-product credits. The Project has 5-10 times higher grade NdPr than a typical ionic clay style rare earth deposit (see table below). It also has low levels of radioactive elements which means easier processing and lower costs.

Being on the site of a past mining operation, the Phalaborwa Project has excellent infrastructure and transport logistics. The Project is largely permitted and positioned in an

established mining region.

Rainbow Rare Earths' two projects have good grade NdPr, especially Gakara

Project	Style	Owner	TREO[4] %	NdPr[5] ppm	Uranium[6] ppm	Thorium[7] ppm
Phalaborwa[1]	Gypsum stacks	Rainbow Rare Earths	0.431%	1,257	2	48
Round Top[2]	Ionic Clay	US Rare Earths/TMRC	0.063%	39	45	179
La Paz[2]	Ionic Clay	American rare Earths	0.04%	80	1	7
Makuutu[2]	Ionic Clay	Ionic Rare Earths	0.08%	232	10	30
Mount Weld[2]	Hard rock	Lynas Rare Earths	7.90%	18,833	30	750
Bear Lodge[2]	Hard rock	Rare Element Resources	3.08%	7,059	113	472
Longonjo[2]	Hard rock	Pensana plc	1.43%	3,170	29	967
Nolan's Bore[2]	Hard rock	Arafura Resources	2.60%	6,859	191	2,700
Norra Karr[2]	Hard rock	Leading Edge Materials	0.55%	758	15	8
Lofdal[2]	Hard rock	Namibia Critical Metals	0.32%	181	18	350
Gakara[3]	Hard rock	Rainbow Rare Earths	13.50%	26,706	97	151



PHALABORWA BENEFITS FROM:

- Greater high-value NdPr grade than a typical low-cost ionic clay rare earth project – closer to grade of traditional hard rock style deposits, which typically have a much higher cost base for mining, crushing/grinding and metallurgical recovery
- Considerable high-value Dy and Tb credits
- Substantially lower levels of radioactive elements than most publicly disclosed rare earth projects

Source: Rainbow Rare Earths company presentation

The Gakara Project (90% interest)

Rainbow states that "the Gakara Rare Earth Project is one of the world's richest rare earth deposits." Rainbow has a 90% interest in the Gakara Project with a non-dilutable 10% owned by the Burundi State. The mining permit covers a large area of over 39km^2 and has a 25-year mining license that began in March 2015.

Gakara was placed on care and maintenance in June 2021 at the request of the Government of Burundi. Primary concerns of the Burundi Government are understood to relate to the pricing of the mineral concentrate currently sold under a long-term off–take agreement with a German company's (ThyssenKrupp), trading arm. Rainbow states: "Rainbow continues to engage constructively with stakeholders to resolve the issue and allow trial mining to recommence as soon as possible."

Highlights of the Gakara Rare Earth Project

Source: Rainbow Rare Earths website

Closing remarks

Rainbow has two exciting African rare earth projects.

The Phalaborwa Project has several advantages including:

1. An ore tailings source, so no need for hard rock mining, crushing, or milling and hence lower production costs.
2. High-value Nd and Pr oxide content representing 29.1% of the total contained rare earth oxides, with low levels of radioactive elements, and
3. An existing mining site with great infrastructure and logistics available.

The Gakara Project has outstanding NdPr grades in visible “veins” and is amenable to simple physical separation of minerals from waste rock to produce a high value rare earth concentrate. This makes for a low OpEx project. The Project is currently on care and maintenance pending the expected resolution of certain legal issues with the government of Burundi.

Risks are typical of those for junior rare earths miners

including funding risk and in this case, sovereign risk in Africa.

Rainbow Rare Earths Limited trades on a market cap of £ 78 million (~US$105 million). One to follow with great interest.

How the Chinese dominance in the rare earths space creates a barrier for non-Chinese companies to enter the supply chain

In this episode of the **Critical Materials Corner with Jack Lifton**, Jack interviews Ed Richardson, President of American's oldest magnet maker, Thomas and Skinner Inc., and a longtime veteran himself of the permanent magnet manufacturing industry, about the possibility of the revival of an American rare earth permanent magnet industry capable of supplying the needs of the North American market.

In this InvestorIntel interview, which may also be viewed on YouTube (click here to subscribe to the InvestorIntel Channel), Ed went on to explain how the Chinese companies are competitive in the rare earths space and how the Chinese dominance in the rare earths space creates a barrier for non-Chinese companies to enter the supply chain. Jack and Ed also discussed how China is using rare earths raw materials from other countries to expand its magnet-making capacity to satisfy its own local demand.

To watch the full video, click here

About Thomas and Skinner Inc.

Thomas & Skinner is the world's leading manufacturer of cast and sintered alnico magnets, magnetic assemblies, and transformer laminations. Through its wholly owned subsidiary, Ceramic Magnetics, Inc., Thomas & Skinner is also a leading manufacturer of soft ferrite magnets. They are committed to providing our customers with the highest-quality, highest-performing magnetic materials available.

To learn more about Thomas and Skinner Inc., click here

value of its securities. Prospective investors are urged to review the Company's profile on Sedar.com and to carry out independent investigations in order to determine their interest in investing in the Company.

If you have any questions surrounding the content of this interview, please email info@investorintel.com.

Critical Materials for the Two American Economies, The Military and the Consumer

Today's demand for critical technology enabling materials was originally brought about by (industrial) policy driven military procurement during, after, and since World War II. The continuing production of these relatively scarce materials is only made economically today possible by the additional and much larger demand of the consumer economy based not on an industrial policy but on the (regulated) free market model of capitalism. Pentagon procurement of its needs for critical materials through policy can bend the law of supply and demand, but it cannot break it. The demands of the free market economy (in the USA) drive the creation of it's critical material's supply. The present (2021) needs of the Department of Defense (DoD) for rare earths, mainly as permanent magnets, for example, are "classified," but are around 3,000 tons, measured as magnets per year. This is not enough demand for private capital to make an investment in a project that requires an entire supply chain to be (re) established.

The American consumer market from which 80+% of the domestic American rare earth demand arises has well established supply

chains and has not experienced credible politically driven supply constraints. The largest single user of rare earth permanent magnets in the USA, the domestic OEM automotive industry, is faced with the need for a fundamental shift in its use of capital if it attempts to restore a total domestic rare earth permanent magnet supply chain for its demand. The best way for such restoration would be vertical integration, the antithesis of today's just in time system of sourcing components. For any individual automotive OEM the costs would be prohibitive and not only is the expertise not available in-house, but also the lack of suitable domestic personnel to carry out such a project, or to manage, or to engineer it is palpable.

The American administration's latest announcement on how it will address the supply chain "crisis" is wrongheaded and misguided. The related bill in the U.S. Senate to promote "innovation" is another misguided use of taxpayer borrowing ability. This, "borrowing ability" is, in fact how the US government is financed; its debt so far exceeds its revenues that to speak of spending in Congress is to describe moneyholics, drunk on their power, and putting the future on a tab.

Washington's aging and apparently permanent lawmakers, such as Senator (D-New York) spout drivel written by their jejune staffers about innovation as science, which, of course, means funding of University and internal government "grant mills." The urgent need in America is for manufacturing "technology," the engineering of science to, modernize, rebuild, and utilize specialized legacy technologies. We do not do endless laboratory work to invent new ways to do things that industries can already do as efficiently as possible while remaining competitive. This particularly applies to capital intensive industries such as mining, automotive, and electronics.

The lithium-ion battery manufacturing industry is a good

example of something completely misunderstood by Washington's insulated, isolated, and commercially illiterate mandarins. From Xanadu on the Potomac, the Biden administration decrees that it will bring lithium-ion battery production to the USA by aiming a money missile with a 19-billion-dollar warhead at the "problem."

But investment money is not the problem in commercializing science; it is the projection of positive returns on investment that drive new consumer industries, not innovation on its own. A good example is the American OEM automotive industry. That industry's dominance peaked in the 1950s when a completely vertically integrated General Motors was the number one industrial firm in the world. It was not "innovation" that drove GM to the top; it was superior management that knew how to manufacture, finance, and deliver the company's products to the consumer who either desired that product or could be manipulated into thinking they did. The position of Chief Engineer of a successful OEM automotive company, once held by Henry Ford in his own company, evolved into Vice President, Engineering, perhaps the second most important position in a manufacturing company's management, and the one individual in any company who must know the limitations of his company to develop and manufacture its products.

Today's, so-called, "tech" companies deliver specialized software (computer programs) as brainless toys to infantile adults using the throw-away model of consumer capitalism. Apple, for example, unconsciously mimicking the marketing ploy developed by GM to differentiate itself from Ford, has a new iPhone and Mac every year with "innovations" that only fit into their existing manufacturing supply chains. In order to maintain sales, existing customers must discard their existing products and buy the "new" ones. GM's marketers decided in the early 1920s that the next Chevrolet would be called the 1922 Chevrolet and that thereafter all GM cars would be named by the year they were produced. Other car makers continued to

name models, such as Ford's Model T, but the success of the model-year naming ploy soon caught on. Car makers became fixated on the car's exterior appearance and its passenger compartment and experimented with drive and power trains mostly out-of-sight of the buying public, so that the enormous research, development, and manufacturing engineering processes needing time for development in power trains could be done and tested before being offered for sale.

Safety regulations have contributed a great deal to the fall of the American OEM automotive industry to its present state, where all (both) of the domestic American OEMs have less market cap than just a couple of Wall Street's flavors-of-the-moment "tech" companies that make no profit and never will.

To sell a car or truck in the USA it must meet rigorous safety standards that have forced car makers to produce much more robust and therefore long-lived products. In 1970 GM predicted that the domestic car market in 2000 would be 26 million units per year and that it would need 28 domestic assembly plants to supply its share of that market. What has come to pass is a "mature" (aka, saturated) car market in which there is a vehicle on the road for every American citizen. The prediction of a 26 million unit year is long gone down the memory hole and the total number of assembly plants in North America does not equal what GM predicted for its own 2000 model year needs.

The Defense Department's investments were father and mother to the American technology boom that took place between 1941 and 1973 (The initial funding of the Manhattan "district" and the cancellation of the Space Shuttle). After that, innovation, slowed down considerably as private industry resumed its pre World War II internal funding of science and engineering that brought about the ascendancy of American consumer capitalism and global military dominance. Industries created before World War II, and without government support, included the telegraph, mass produced uniform quality steel and aluminum, the telephone, the light bulb, radio, the automobile, the

airplane, television, the mechanical computer (OK, adding machine), miniaturized electronics, mechanical electric refrigeration, and many others in the life sciences, such as x-rays, insulin, and, originally, penicillin. Although we pay lip service to the inventors of the above “technologies” as intentional promoters of higher living standards, in fact, their driving motive was almost always profit. The scientists whose discoveries led to the technologies listed above are long forgotten or known only to historians; they rarely sought fame or fortune.

It was Franklin D. Roosevelt who kicked off the great age of American innovation in 1941, not just by authorizing the Manhattan Project, but primarily by bringing in the CEOs of GM, Chrysler, Ford, GE, and Westinghouse to oversee the transformation of American free enterprise manufacturing and innovative product development into the industrial policy driven global powerhouse that crushed Nazi Germany, Fascist Italy, and Imperial Japan, all of which began a war to capture the raw materials and land their society’s desperately needed to manufacture the weapons of war and feed their armies.

After World War II a subset of American manufacturers soon known as the “military industrial complex created itself in order to produce products required by the industrial policy, and power to execute it, created by the War (now Defense) Department during the war. The civilian, soon to be known, as the consumer, economy decoupled itself and followed the free enterprise model of capitalism, but it was spillover from military spending that created the miniaturization of electronic switching into the integrated circuit, aka, the “chip,” which sparked a consumer product revolution the basis of which was further inspired by the rare earth permanent magnet the development of which was itself inspired by stylists in the OEM automotive industry who wanted slimmer doors on cars with power windows.

The Ford Scientific Laboratory was working on a sodium sulphur

battery in 1964. I was a “helper” on that project. I didn’t work for Ford but I was being recruited by Ford Scientific for its materials sciences group. I had been working with the electronic properties of Lithium and it’s salts since 1962 at Energy Conversion Devices, my first employer, where we made a molten salt version of what is now known as a lithium ion battery in 1963. These molten salt power train batteries proved extremely inappropriate for automotive use, but my point is that there isn’t much new under the sun other than different ways to do desired things such as energy storage more efficiently and safely. And these today are really engineering problems more so than scientific ones.

The US Defense Department on its own and without subsidies cannot catalyze the reshoring of a total domestic American, lithium, cobalt, or rare earth permanent magnet supply chain. It’s time for the White House to call in the managers of the manufacturing part of the domestic consumer products industry for a chat about the creation and implementation of a national industrial policy.

Only through a Secure Supply of EV Metals (Rare Earths) can a Hegemony Be.

It has been reported today that the Biden administration is looking to allied nations as primary sources of critical mined raw materials, and that it, the administration, will focus on supporting the domestic American processing of such imported ores into useful products focused on domestic production of EVs, their batteries, and components. This is an example of a

complete disregard by the Biden administration for America's competitive advantage, safety, and, ironically, its economy to placate a loud anti-mining luddism that pervades the American left. It is in two words, hypocritical and stupid. It's hypocritical because it assumes that out-of-sight, out-of-mind, will placate the left's "greens" into thinking that pollution in Australia, Canada, or Brazil and its attendant costs doesn't exist. It's stupid, because it makes no economic sense. Transporting raw material concentrates to the USA for processing is rarely cheaper than mining and processing them domestically. In the case of cobalt, for example, its "ore" is mostly a byproduct of copper or nickel production, and there is no cobalt mine in the USA and there is only one facility in North America (Canada) capable of processing the ore concentrate into "battery grade" cobalt. In the case of the rare earths almost all ores are radioactive and thus have to be "cleaned" at licensed and specialized facilities. Only one such private facility exists today in the USA.

There is today no commercial rare earth separation, metal making, alloy making, or rare earth permanent magnet manufacturing in the USA. The combined annual demand of the military and consumer industries in the USA for rare earth permanent magnets is between 10,000 and 15,000 tons per year. Never in American history has so much of any of these forms of rare earths been produced in a single year.

Yet Washington believes that the annual processing into fine chemicals and metallurgical forms of 170,000 tons each of lithium and cobalt (the amount required annually for 17 million BEVs if each has a 60 kWh battery [the smallest battery now offered by Tesla]) and of 50,000 tons per year of rare earth permanent magnets (the amount required by 17 million EVs annually if each uses one rare earth permanent magnet motor) could be accomplished by 2030.

The Biden administration's plan for sourcing critical materials for EVs is also an indication of the end of American

dominated natural resource globalization and the acceptance of the fact that China has already constructed and is operating a global sourcing system for critical materials for China's domestic economy, which includes an emphasis on domestic Chinese processing of the ores of critical materials and a total domestic Chinese supply chain for the end-use products that depend on downstream forms of the critical materials for their operation and use both in the civilian and military markets. China today processes 60% of the world's lithium and 80% of the cobalt as well as 90% of the rare earths!

China has published its China2025 plan to become independent in 10 key technologies by 2025. Its globalization of secure sources of technology materials to ensure the success of China2025 is for all practical purposes already complete, as planned.

It is said that we live in the age of technology, and that we are all enjoying the fruits of applied science (aka, technology), but we have to ask "What is the purpose of a technology, in human terms?" Is it the jobs and spin-offs from the manufacturing and distribution of high-tech, consumer-oriented, and quality-of-life-improvement -goods to the general population through the economies of miniaturization, which alone makes them economically available? Is it primarily for military uses? Is it for both, the civilian and military markets, needs, and satisfaction?

For the fifty years from the successful conclusion of the manned lunar landing program in 1969 until today the target of technology has been upon making economically available business and leisure travel (civilian jet passenger and freight airliners), making individual wireless mass communication, both audio and video, cheap and available, and making electrical energy universally available and affordable.

The last of these, the universality of cheap available electric power, is now the basis of our technological

civilization!

Unquestionably it was military patronage of science and engineering from 1940 to 1970 that brought about the discovery of deposits, production, and processing of the technology metals that enable the miniaturization, and thus widespread consumer availability, in today's society, of high-tech goods and services. But since President Nixon canceled the Space Shuttle Program in 1973 original research for product development in the USA has been the purview of private industry.

We are now at a turning point.

There are two directions to go for the need to have secure supplies of **technology enabling metals.**

One is to let the free market system as practiced in the USA make sure that items are always available through demand driven supply. The USA maintains a (ridiculously) small supply of critical materials for the Defense Department in case of emergencies, and private industry balks at inventory costs.

The other is to formulate and act upon an industrial policy, with which the State mandates a supply agenda and sets production quotas for all companies involved in a particular technology enabling metal supply chain. The Chinese government maintains large stocks of technology enabling metals to smooth out both demand spikes and prices.

The United States' financial system, known as free market capitalism, operates as if profit is the sole purpose of the existence of any manufacturing or service enterprise. China has adopted a Capitalism with Chinese Characteristics in which the sole purpose of any Chinese venture is to do something which is good for China. Private enterprise is allowed, and individuals may accumulate enormous wealth if and only if this purpose, the good of China, is the goal.

A hegemon is the first among equals. Athens was the first to be known as a hegemon, followed by Alexander’s Macedon, then Imperial Rome, and more recently, the British Empire, and the United States. In 1947 America had half of the world’s gold, produced half of the world’s steel, the most powerful military in history, and was embarking on an unparalleled era of technological brilliance.

There can only be one hegemon, by definition.

Globalization of the sourcing of critical materials with American characteristics (Neoliberal, free market, economics) can’t work. It’s too late.

To paraphrase the poet: This is how hegemony ends. Not with a bang but with a whimper.