HYPERIONMETALS.US

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2021 DRAFT LIST OF CRITICAL MINERALS

Abstract

The CML is a useful tool in identifying critical minerals to the U.S., however in the case of titanium sponge it is clear that the underlying CML methodologies have not identified the extremely critical nature of this material in isolation. This is caused by two key factors:

1. The use of outdated information in the CML methodology
2. The grouping of critical minerals within a supply chain, including titanium minerals and pigments

Evidence of this oversight is clear when the criticality of titanium sponge to the U.S. is assessed objectively using current information and in isolation to other titanium products.

This is further confirmed when the ranking of titanium sponge is contrasted to other inclusions in the CML, such as aluminum. When titanium sponge and aluminum are compared side by side, it is clear that titanium sponge is more critical to the U.S., a fact that is not currently reflected in the CML.

Hyperion recommendations to rectify this oversight include engaging subject matter experts to review the CML for key changes that may have occurred post-reporting date, as well as separately assessing critical minerals within a single supply chain, such as titanium sponge, titanium minerals and titanium pigments.

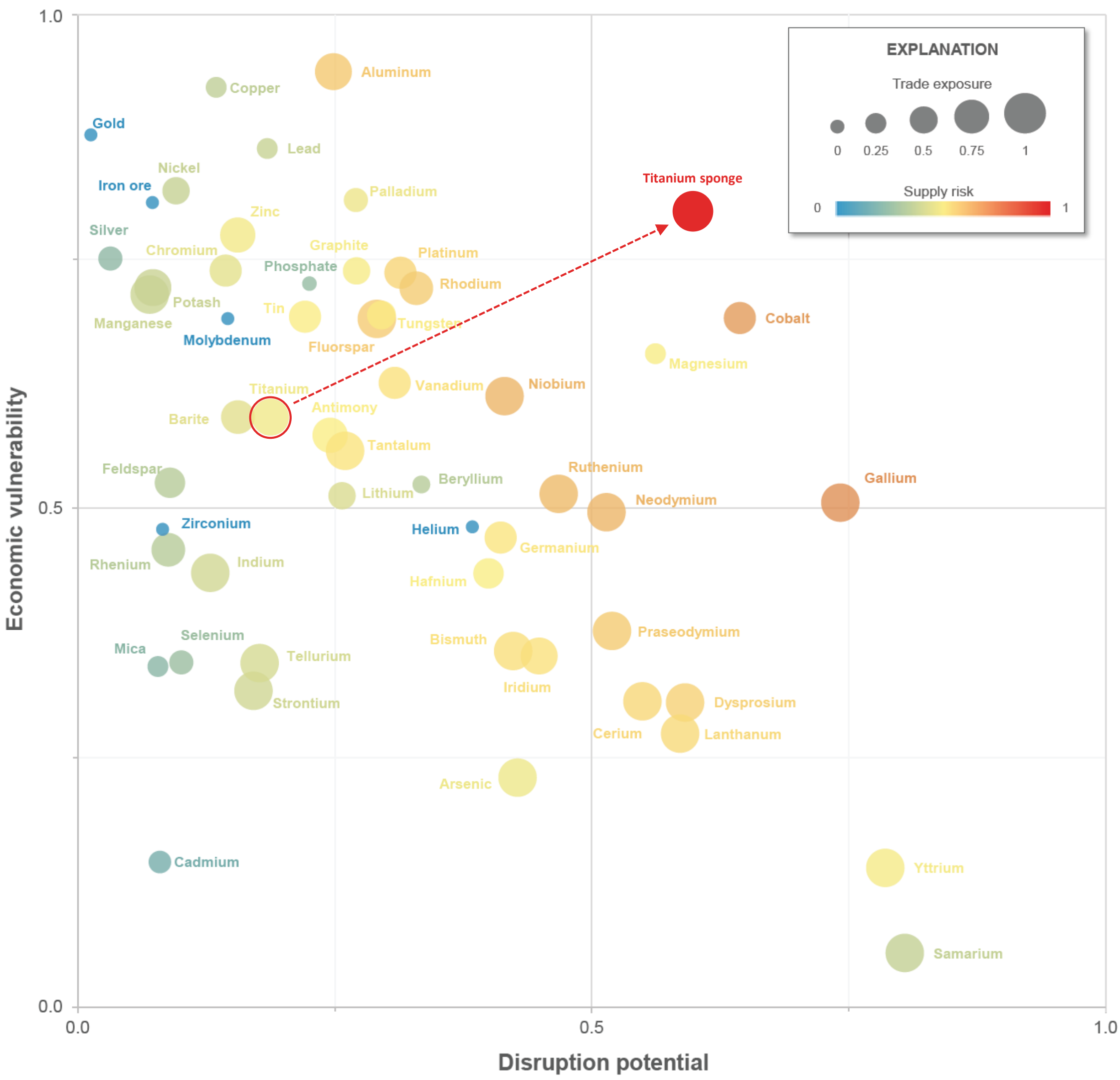


Figure 1: Restated assessment of mineral commodity supply risk, including the estimated position of titanium sponge in isolation

Introduction

Hyperion Metals ("Hyperion", the "Company") is a U.S. based company focused on the development of a domestic mine to metal U.S. supply chain for titanium, which as of year end 2020, does not exist in the U.S.

Hyperion supports the establishment and regular review of a national Critical Minerals List ("CML"), however Hyperion notes deficiencies in the methodology used to form the CML, particularly with regard to the information relating to titanium sponge.

Titanium background & facts

Titanium is a strong, lightweight metal with ideal properties for broad applications in defense, aerospace, space exploration, electric vehicles, unmanned vehicles, and many other advanced manufacturing applications.

Primary titanium metal is called titanium sponge, and is produced from converting titanium minerals via the energy intensive and expensive Kroll process. Titanium products are produced by the melting of titanium sponge into semi-finished goods (ingot, billet) which are then used to create final products (wire, plate, bar, sheet).

In the report publicly delivered in June 2021 by the U.S. Department of Commerce Bureau of Industry and Security, *The Effect Of Imports Of Titanium Sponge On The National Security*, it is noted that Congress has recognized that titanium sponge is critical to national security by including titanium as a strategic material in the Specialty Metals Clause, with all titanium used in national defense systems directed to be melted or produced in the United States or a qualifying country.

Further, the Department of the Interior's 2018 List of Critical Minerals established titanium as essential to U.S. security, and found that the absence of a titanium sponge supply would have significant consequences for the U.S. economy and the national security.

The U.S. was the first nation to commercialize titanium sponge production in the 1950s. In 1984, there were five plants producing titanium sponge in the U.S. but by 2019, only one producer was capable of producing titanium sponge for defense, commercial, and industrial purposes. That final production facility closed in 2020 and now the U.S. has no commercial titanium sponge production capacity and is 99.9% import reliant to produce semi-finished and final products.

Titanium sponge – national security considerations[1]

The U.S. now has minimal commercial titanium sponge production capacity, a critical material for many U.S. defense systems, including fighter jets, bombers, attack aircraft, transports and helicopters, with newer aircraft using increased amounts of titanium.

Titanium Content in Select U.S. Military Airframes		
Airframe	**Introduction into Service**	**% of Titanium Content**
CH-47 Chinook	1962	8
F-15 Eagle	1976	10
F-16 Fighting Falcon	1978	7
F/A-18 Hornet	1984	12
F-22 Raptor	2005	39
V-22 Osprey	2007	31
F-35 Lightning II	2015	20
Military airframes entering service after 2000 have an average 30 percent titanium content; airframes entering service prior to 2000 had an average of just 9 percent.		
Source: Arconic Engineered Structures, "World Titanium Trends in Defense", Presentation at the Titanium USA conference, September 24, 2019		

Titanium is frequently deployed in applications which require high strength and low weight, such as the A-10 Thunderbolt II attack aircraft, where a titanium cockpit tub has proved vital to the safe return of pilots despite heavy damage from enemy ground fire.

[1] Extensive direct references to U.S. Department of Commerce Bureau of Industry and Security Office of Technology Evaluation document, *The Effect Of Imports Of Titanium Sponge On The National Security*, November 29, 2019

Titanium is also extensively used in naval applications due to is excellent anti-corrosion characteristics, as well as army ground vehicles due to its very high strength and light weight.

In 1988, U.S. titanium sponge production could fulfill all domestic consumption. By 2018, production at the last operational sponge facility fulfilled just 28% of domestic consumption[2] and by 2021 the U.S. had no meaningful production capacity. In an emergency scenario where imports were disrupted, U.S. downstream producers may not be able to continue normal melting and fabrication operations without access to titanium sponge and scrap imports.

Currently only Japan, Russia, and Kazakhstan have titanium sponge plants certified to produce aerospace rotating-quality sponge that can be used for aerospace engine parts and other sensitive aerospace applications. In 2018, Russian and Chinese titanium sponge producers controlled 61% of the world's titanium sponge production, an increase on their combined 55% share in 2008 and 37% share in 1998. In 2021, Russia and China's control of global titanium sponge production is likely to increase to over 70%

Absent domestic titanium sponge production capacity, the U.S. is completely dependent on imports of titanium sponge and scrap, and lacks the surge capacity required to support defense and critical infrastructure needs in an extended national emergency.

Given the lack of domestic production capacity, and that the U.S. no longer maintains titanium sponge in the National Defense Stockpile, titanium producers, including producers of goods such as ingot, billet, sheet, coil, and tube, are almost all entirely dependent on non-U.S. sources of titanium. This presents the possibility that in a national emergency, U.S. titanium producers would be denied access to imports of titanium sponge and scrap due to supply disruption.

Recommendation #1 – use of updated information

Select information used in the CML quantitative assessment methodology is sourced from published USGS documents, including the USGS Minerals Yearbook as well as USGS Mineral Commodity Summaries.

These documents are excellent sources of information, however it appears that the CML methodology utilizes the balance date statistics provided in these documents, and does not consider other insights that the documents provide, particularly relating to post-balance date events.

As an example, page 174 of the USGS Mineral Commodities Summary 2021 for titanium states:

"Titanium sponge metal was produced by two operations in Nevada and Utah. Production data were withheld to avoid disclosing company proprietary data. The facility in Salt Lake City, UT, with an estimated capacity of 500 tons per year, produced titanium that was further refined for use in electronics. Sponge operations in Henderson, NV, with an estimated capacity of 12,600 tons per year, were idled at year end owing to market conditions. A third operation, in Rowley, UT, with an estimated capacity of 10,900 tons per year, remained on care-and-maintenance status since 2016.

From this paragraph, it is evident that as of the end of year end 2020 the U.S. actually has no meaningful titanium sponge production. In contrast, utilising the USGS data allows the potential for ~13,000 tons of capacity to be represented in the CML quantitative assessment calculations.

Whilst the information is withheld by the USGS to avoid disclosing proprietary data, a simplified example of the potential impact on the CML quantitative assessment results for the Trade Exposure metric is below.

CML, titanium sponge trade exposure (2020)

$$TE = (I - E + \Delta S) / AC$$

$$\mathbf{0.66} = (24{,}000 - 1{,}000 + 0) / 35{,}000$$

Titanium sponge trade exposure (2021)

$$TE = (I - E + \Delta S) / AC$$

$$\mathbf{0.99} = (34{,}500 - 0 + 0) / 35{,}000$$

TE = trade exposure, I = total U.S. imports, E = total U.S. exports, ΔS = change in U.S. industry and government stocks, AC = U.S. apparent consumption.

[2] USGS Titanium and Titanium Dioxide Annual Publication, 2021 and Roskill, 2021

This highlights the potential risks to the CML of utilising outdated information, which include:

1. Exclusion of critical minerals from the CML
2. Inclusion of non-critical mineral in the CML
3. Incorrect quantitative assessment ranking in the CML

The example provided in the Trade Exposure calculation for titanium sponge has the potential impact of incorrectly lowering the ranking of titanium in the CML, thus underrepresenting its criticality.

Recommendation: Hyperion recommends that subject matter experts for each mineral or material review the data and CML for key events or changes in the relevant supply chain that may have occurred post-reporting date for the data used in the quantitative assessment.

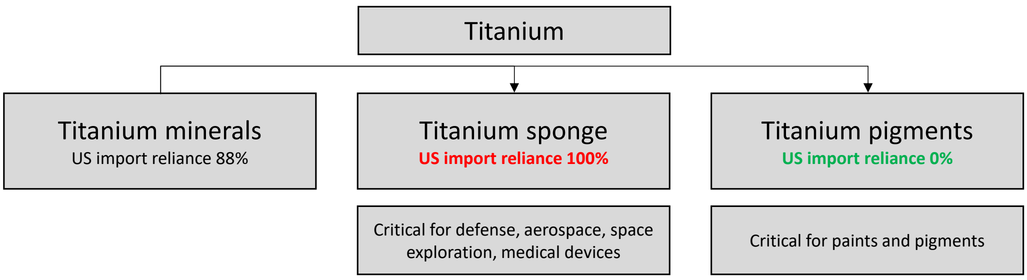
This is particularly important given that the CML is scheduled to be reviewed every three years, and in the example of titanium sponge, may underrepresent the criticality of this material to key stakeholders who rely on the CML information.

Recommendation #2 – separation of the reporting of critical minerals within a single supply chain

The CML consideration of "critical minerals" is defined under the Energy Act of 2020 to include *"….minerals, elements, substances or materials….".* It is noted that the CML methodology groups various different minerals or materials of a supply chain as a single critical mineral, creating the risk over/under representing the criticality of a particular mineral within that grouping through the calculation of an "average" supply risk score.

As an example, the CML only reports and provides a quantitative assessment for the critical mineral titanium. In contrast, the USGS typically reports titanium in three categories: i) titanium minerals, ii) titanium sponge, and iii) titanium dioxide pigment. These three categories of titanium have vastly different levels of criticality, which should be viewed separately, as demonstrated by the conceptual criticality assessment below:

- ***Titanium minerals*** – moderately critical – high U.S. import reliance, fragmented producer base and numerous U.S. import sources
- ***Titanium sponge*** – highly critical – 100% U.S. import reliance, producer base dominated by adversarial nations, highly concentrated U.S. import source (SPOF – Japan), used in extremely sensitive and high value applications
- ***Titanium pigments*** – not critical – 0% U.S. import reliance (net exporter), used in non-sensitive and lower value applications



Global producers		Global producers		Global producers	
China	30%	**China**	**52%**	China	48%
South Africa	13%	Japan	24%	USA	16%
Australia	11%	Russia	16%	ROW	9%
Canada	9%	Ukraine	3%	Germany	6%
US importers		**US importers**		**US importers**	
South Africa	39%	**Japan**	**90%**	Canada	38%
Australia	20%	Kazakhstan	7%	ROW	27%
Madagascar	10%	Ukraine	2%	China	22%
Mozambique	9%	Other	1%	Germany	9%

Figure 2: Global production and U.S. import reliance on titanium minerals, titanium sponge and titanium pigments

In this scenario, if titanium sponge were considered as a critical mineral separate to other forms of titanium, it is likely to have a much higher quantitative assessment ranking. Based on the current methodology, titanium sponge's criticality is likely to be underreported in the CML, creating potential risks for strategic industries such as defense through a lack of focus on current weaknesses in the U.S. supply chain.

Recommendation: Where relevant, Hyperion recommends that consideration is taken to separate the reporting of critical minerals within a single supply chain, to avoid the calculation of the averages of various components of a supply chain for quantitative assessment purposes, to represent the true relative importance of various critical mineral to the U.S.

Case study – incorrect CML ranking highlighted by the comparison of aluminum and titanium sponge

A case study of an incorrect outcome in the CML is the comparative rankings of aluminum and titanium of #8 and #26 respectively, with aluminum determined as more critical than titanium. However, when the mine to metal supply chains for aluminum and titanium sponge are compared (as opposed to the average value for all titanium categories), it is clear that titanium sponge should be ranked far higher than aluminum in terms of criticality, particularly given its importance to national security, relative import reliance and the concentration of nations that imports are sourced from.

National security

U.S. national security requirements for aluminum are mostly covered by U.S. domestic production. The amount of aluminum required by national defense and homeland security is small, accounting for only ~2% of the U.S. total domestic consumption of aluminum, and less than 4% of the U.S. total domestic supply of aluminum. Further, the clear competitive and technological edge enjoyed by the U.S. aluminum industry ensures a continued and reliable supply of U.S. domestic aluminum for defense and national security.

In comparison, U.S. national security requirements for titanium sponge are entirely supplied by imports, with adversarial nations including China and Russia having huge influence over the global supply chain, a significant threat to U.S. national security.

Single point of failure / trade exposure

The U.S. only accounts for 4% of the global production of aluminum, yet manages to support most of its U.S. national security requirements for aluminum through U.S. domestic production. In the unlikely event that U.S. domestic production is negatively impacted, the U.S. has multiple alternate sources of aluminum that can be reliably sourced from many OECD and NAFTA countries, including both neighbors Canada and Mexico. Further, aluminum is an exchange trade commodity, with global market prices determined by the London Market Exchange on the basis of global supply and demand.

In the case of titanium sponge the U.S. effectively has a single point of failure in its import supply chain, sourcing 90% of its supply from a single country, Japan. Further, adversarial nations including China and Russia control approximately 70% of global production, with significant investments currently being made in these countries to further grow titanium sponge production capacity at a time when the U.S. has reduced its capacity to zero.

Titanium

Titanium minerals (US import reliance 88%)		Titanium sponge (US import reliance 100%)	
Global producers		**Global producers**	
China	30%	China	**52%**
South Africa	13%	Japan	24%
Australia	11%	Russia	16%
Canada	9%	Ukraine	3%
US importers		**US importers**	
South Africa	39%	Japan	**90%**
Australia	20%	Kazakhstan	7%
Madagascar	10%	Ukraine	2%
Mozambique	9%	Other	1%

Aluminum

Bauxite (US import reliance >75%)		Alumina (US import reliance 49%)		Aluminum (US import reliance 13%)	
Global producers		**Global producers**		**Global producers**	
Australia	30%	China	54%	China	57%
Guinea	22%	Australia	15%	ROW	14%
China	16%	Brazil	7%	India	6%
Brazil	9%	India	5%	Russia	6%
US importers		**US importers**		**US importers**	
Jamaica	37%	Brazil	47%	Canada	50%
Guyana	21%	Australia	26%	UAE	10%
Australia	16%	Jamaica	12%	Russia	9%
Brazil	11%	Canada	5%	China	5%

Figure 3: Global supply chains, production and U.S. import matrix for titanium sponge and aluminum

Economic vulnerability

Titanium sponge is the precursor to titanium metal, used in a huge range of high end and extremely valuable applications to the U.S. economy, including aerospace, space exploration, automotive sector and medical sector. This is economic vulnerability is not reflected in the CMI, with the lesser valuable titanium feedstock and pigment industries "diluting" the relative vulnerability of titanium sponge.

Conclusion

The CML is a useful tool in broadly identifying critical minerals to the U.S., however in the case of titanium sponge it is clear that the underlying methodologies have not identified the extremely critical nature of titanium sponge in isolation, as opposed to other titanium products – including of titanium minerals and titanium pigments.

This is cause by the use of outdated information in the CML methodology and the grouping of critical minerals within a single supply chain.

Hyperion recommendations to rectify this oversight include engaging subject matter experts to review the CML for key events or changes that may have occurred post-reporting date as well as separately assessing critical minerals within a single supply chain.

APPENDIX 1 – ABOUT HYPERION METALS

Hyperion's mission is to be the leading developer of zero carbon, sustainable, critical material supply chains for advanced American industries including space, aerospace, electric vehicles and 3D printing.

Hyperion holds a 100% interest in the Titan Project, covering approximately 11,000 acres of titanium, rare earth minerals, high grade silica sand and zircon rich mineral sands properties in Tennessee, USA.

Hyperion has secured an option to acquire Blacksand Technology, LLC, which holds the rights to produce low carbon titanium metal and spherical powers using the breakthrough HAMR & GSD technologies. The HAMR & GSD technologies were invented by Dr. Z. Zak Fang and his team at the University of Utah with government funding from ARPA-E.

The HAMR technology has demonstrated the potential to produce titanium powders with low-to-zero carbon intensity, significantly lower energy consumption, significantly lower cost and at product qualities which exceed current industry standards. The GSD technology is a thermochemical process combining low-cost feedstock material with high yield production and can produce spherical titanium and titanium alloy powders at a fraction of the cost of comparable commercial powders.

Hyperion also has signed an MOU to establish a partnership with Energy Fuels (NYSE:UUUU) that aims to build an integrated, all-American rare earths supply chain. The MOU will evaluate the potential supply of rare earth minerals from Hyperion's Titan Project to Energy Fuels for value added processing at Energy Fuels' White Mesa Mill. Rare earths are highly valued as critical materials for magnet production essential for wind turbines, EVs, consumer electronics and military applications.

Hyperion Metals Ltd
hyperionmetals.us

U.S. Head Office
129 W Trade Street, Suite 1405
Charlotte, NC 28202

More Information
info@hyperionmetals.us
+1 704 461 8000