# How Failure Is Hard-Baked into U.S./Western REE Policy

## *An Evaluation of*

## *MP Materials & Lynas VS China and Other REE Producers*

***(Based on* Comparative REE Distributions, Current Cost Data, & Metal Production Subsides*)**

## *And a Proposed Solution*

***(S. 2093 & H.R. 4410)***

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***Sources provided at the end**

# Pentagon's Pathway to Failure – Deja Vu All Over Again

The Pentagon's two choices to solve the long-standing critical materials supply issue are irredeemably flawed on a number of levels.

> The Pentagon's support for MP Materials (MP) is a repeat of its choice to back Molycorp; it is the exact-same incompatible and non-economic deposit.

This presentation breaks out the problematic geochemistry of these deposits and how it translates into:

- Highly unfavorable elemental distributions resulting in processing losses
- Economic instability due to over reliance on just two of the 16 elements
- Resource incompatibility with U.S. technology and defense needs

The resulting resource limitations and history of economic uncertainty make these producers unsuitable candidates on which to build a fully integrated rare earth value chain for our economy or national security.

# Starting Point Conditions

Rare earth concentrates, currently produced by MP, and mixed oxides and separated oxides, currently produced by Lynas, have no meaningful technology or defense application.

Most of these materials are shipped to China to be fully separated and converted into metals, alloys, magnets or other application specific products.

Metallic REEs represent nearly 95% of the total economic value of rare earths in the world's economy and China controls close to 100% of "new" metal (from virgin ore).

The Pentagon has committed hundreds of millions of dollars to upgrading these two mining companies' capabilities to the point of fully separated oxides, but:

1) no amount of money can overcome the geochemical shortcomings of these two deposits (their naturally occurring distribution of REEs), and
2) the scale of China's subsidies at the metallic conversion level that make any plans for domestic metal production unrealistic / uneconomic.

# Assumptions

The REE production numbers for MP & Lynas are taken from their respective corporate news releases.

The REE distribution numbers were taken from USGS and corporate documents.

The estimated average production cost for 1 Kg of REE oxide was derived from financial reports produced by Lynas in 2019, at $9.98 per Kg

The same cost is applied to MP in the following analysis.

> Claims that MP will have lower REE production cost can be dismissed as lower cost do not materially alter the comparative economics, as it is primarily a function of REE distribution, and
>
> Historically, just prior to Molycorp's bankruptcy in 2015, Molycorp was estimating sub $3 per Kg production cost while Lynas told investors its per Kg cost was in the range of $14 to $15 costs – but it was Lynas that survived.

# Other Objections

Other anticipated objection to the following analysis may be over the applied cost for producing Cerium (Ce) and Lanthanum (La) and the other low value REEs in direct proportion to their natural distribution.

Company or industry analysts may claim that little or no cost should be applied because these companies intentionally dispose of Ce and / or La before it is fully converted into an oxide.

- While this may be true, substantial proportional costs go into mining, crushing, milling and digesting these elements before they can be rejected.
- Furthermore, this sort of selective rejection processing typically results in lower recovery of some of the higher value REEs – thus impacting relative values.

The take-away is that the applied cost are much less relevant than the deposits' naturally occurring REE distribution.

# Application of Cost

The all-in estimated cost of separated REE oxides produced by MP and Lynas, to include the recently funded Pentagon processing facilities, are impossible to estimate.

For simplicity sake, this analysis uses $10 per Kg as a proxy cost.

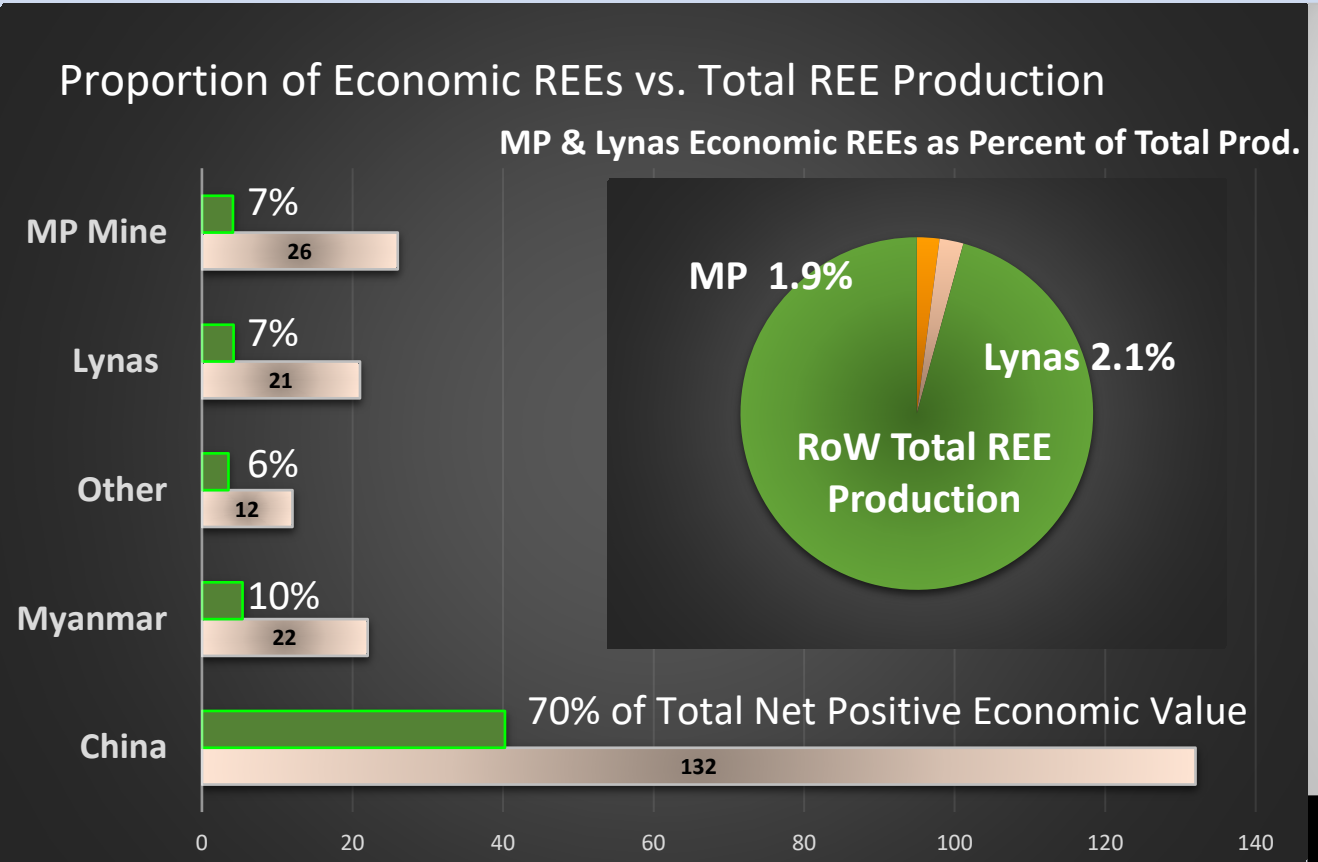
China's costs are estimated to be 30% lower, so $7 per Kg was used.

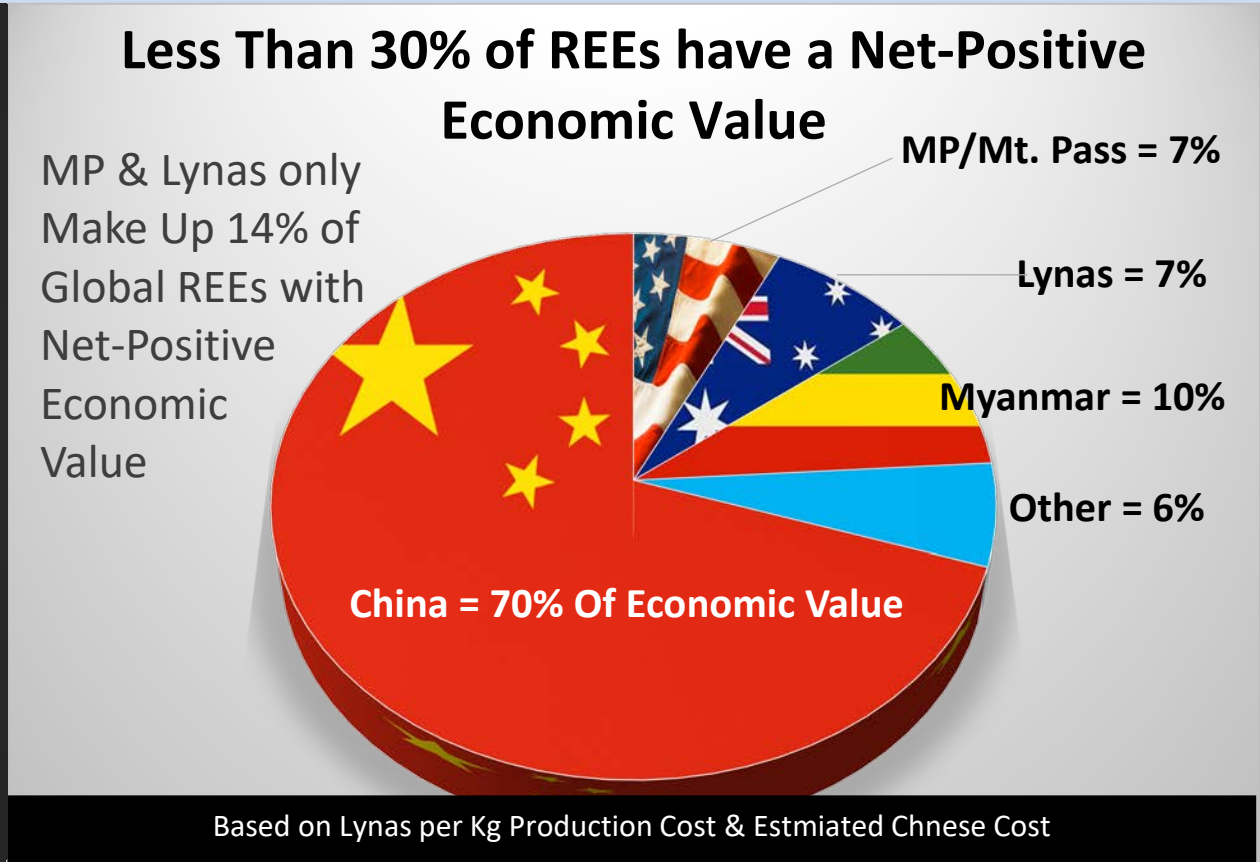
If someone has a problem with any of these assumptions, they need to consider that any proportional adjustment across all included deposits results in proportional economic outcomes (also see end-notes on MP/Molycorp cost claims).

In the analysis that follows, a $10 production cost was applied to REEs selling below $10 (and a $7 cost for China) and multiplied by the proportional distribution of that element, to calculate the corresponding processing losses for all deposits listed below.

## Over time, non-Chinese REE producers like MP & Lynas will become non-competitive and irrelevant

- The percentage of their ore body that is not economic (selling below production cost).
- The relative REE distribution of the economic portion: too little Terbium, Dysprosium, Lutetium, Scandium, etc.
- Economic overdependence on just two elements: Praseodymium & Neodymium.
- Disparities in capital, environmental, labor, permitting, social licensing and land acquisition & access costs.
- Non competitiveness with Chinese, Asian, African & other Actinide bearing resources with lower production cost & higher economic distributions (Actinide bearing resources are a byproduct of existing/operation U.S. mines, with no direct mining cost. Examples of Actinide bearing resources/REE distributions/relative economics are included).



# Visualizing the disparity in economic value

This slide shows the economic value of each element for each deposit and relative "Net Basket Value".

The combined value for each deposit is calculated at 100 kgs to highlight relative disparity.

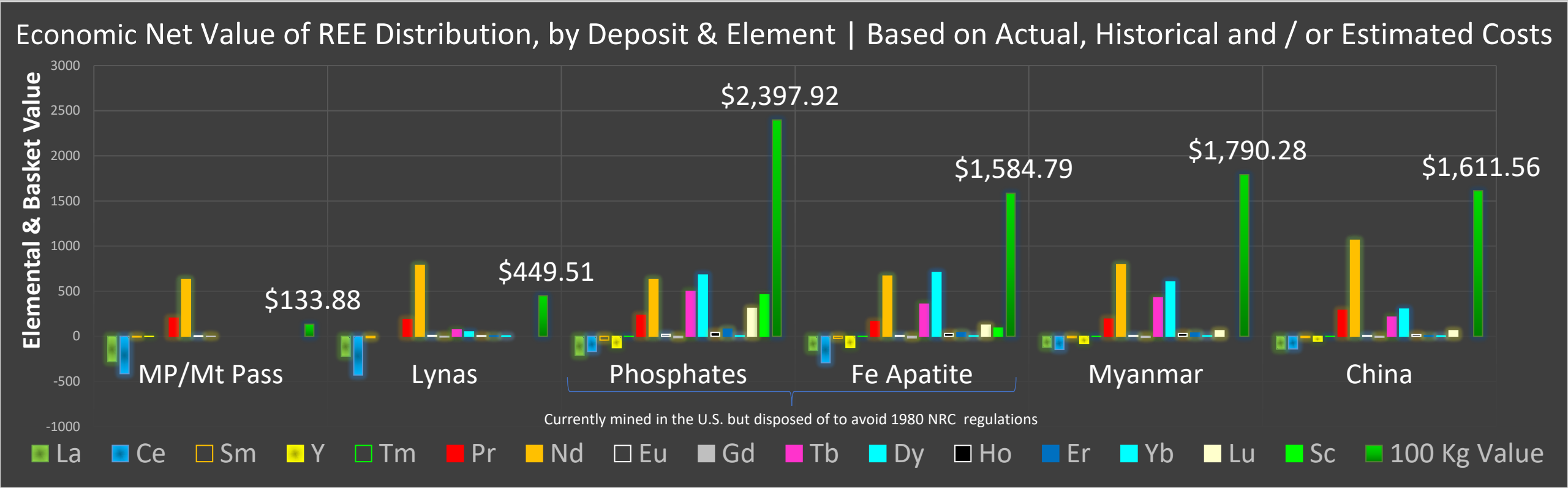
Note: The MP and Lynas Net Basket Values were calculated at a cost of $10 per Kg.

## Using the MP / Lynas proxy cost of $10 per Kg vs. $7 for China:

MP's comparative economic value is less than 10% of China's

Lynas's comparative economic value is less than 30% of China's

Assuming MP could somehow produce at the same cost as China, its Net Basket Value would only increase to $384, leaving China with a 75% cost advantage.

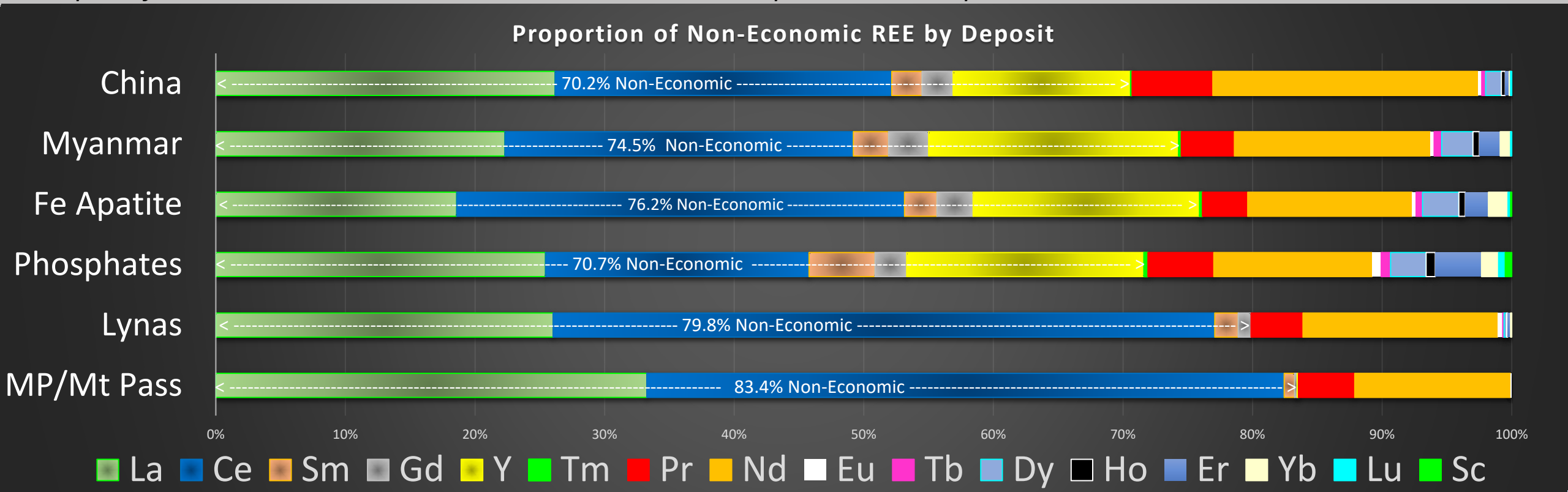


# The proportion of Non-Economic REEs is a function of geochemistry

Low actinide bearing deposits, targeted to avoid “source material’ regulations, are economically inferior.
These resources tend to be very low in Terbium and Dysprosium, critical for military grade magnets.

Byproduct resources from Phosphates are mined every day in the U.S., but disposed of to avoid regulation.
Other resources, with similar REE distributions, are also mined & disposed of for the same reason.
These resources have no direct mining cost & are considered a liability by most producers.
The amount of these potential resources exceeds non-Chinese world demand (RoW).
Utilizing these resources would help the U.S. and RoW be more competitive.

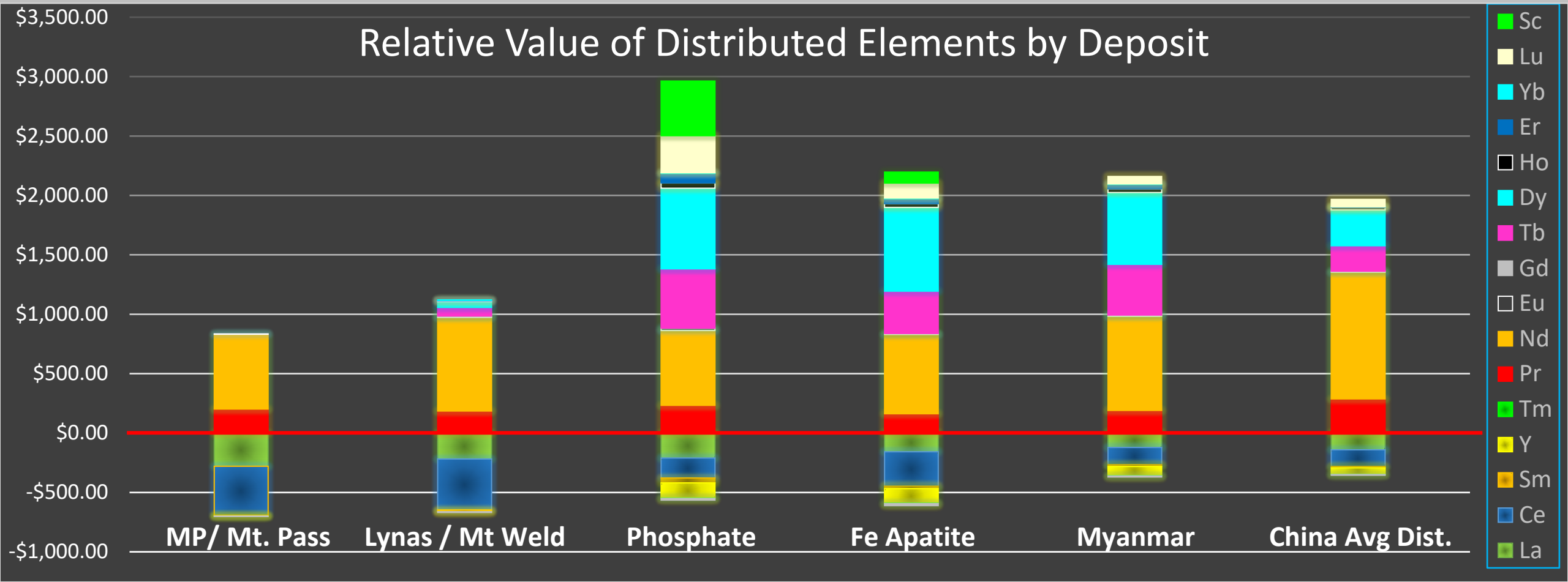
*Examples of abundant and available actinide resources like Phosphates and Fe Apatite are included below*



# A Closer Look: The proportional economic contribution of each element by deposit

MP/Lynas overabundance of Cerium & Lanthanum undermine their economics.
MP/Lynas deficiencies in Terbium, Dysprosium & other HREEs equate to an economic/tech/defense vulnerability.
MP/Lynas resource economics are dwarfed by China, Myanmar and other rapidly developing producers.

The U.S. and RoW need an alternative to MP/Lynas & other low Actinide / REE-only resource producers.
Currently mined REE resources from Phosphates and others are diversified and more economically robust.



# The Economic Viability of MP and Lynas Uncertain, vs New Low Cost Asian and African Producers Like Myanmar

## MP is incompatible with U.S. Economic & National Security needs because:

- it cannot produce 2/3 of the economic REEs used by Tech & Defense.
- it cannot produce Tb & Dy, elements critical in most military magnets, and
- the value of MP's REE distribution is less than 10% of the value of China's.

## Lynas is marginally better in a number of ways, but:

- its logistical costs are extensive (spanning multiple facilities over three countries),
- its REE distribution is less than 1/3rd the value of China's
- it produces 70% less heavy REEs than China and 88% less than Myanmar

Neither company has proven technology or a track record for separating all of the REE oxides.

Neither company is a resilient candidate for supplying a domestic REE metallurgical value chain.

# US Mining Solves China's Problem, Not America's

Mined resources have no meaningful technology or defense application.
Close to 95% of all economic value from rare earths is in its metallic form.
China controls REEs at the point of metal production:

- China currently mines or controls over +70% of the world's REE resource
- China currently refines +80% of the world's mixed oxides
- China currently separates +90% of the world's elemental oxides
- China currently produces or controls close to 100% of "new"* REE base metals
- Nearly 100% of new alloys & magnets are produced with Chinese controlled metal

China's new strategy is to let other nations do the dirty work of mining & refining as long as they feed China's metallurgical capacity.

It is unrealistic to believe that the U.S. & RoW can subsidize their way out of this problem. Even if they could, the correspondingly necessary heavy REEs are deficient.

** "New" metals, alloys & magnets are produced with 100% virgin REE oxides. Japan & Germany produce REE metals from recycled and semi-recycled materials*

# An example of the scale of subsidization for Chinese metals

| | | |
|---|---|---|
| Neodymium Oxide price for 1.15 Kg* of Nd Oxide purified to 99.9 % | = $368 | 1.15kg* |
| Neodymium Metal price for 1 Kg of Nd Metal purified to 99.9 % | =$407 | 1 kg |
| Iron Oxide price for 1.4 tons of Fe304* purified to 65% Fe | =$135 | 1.4 tons* |
| Steel price for 1 ton of finished steel (standard-grade) | =$600 | 1 ton |

Chinese metal pricing may not cover the cost of energy necessary to convert the REEs to metal

**Adjusted for oxide to metal conversion (Nov. 2019 pricing)*

**The value-add for converting iron ore to common steel is over <u>400%</u>, yet China's mark-up for converting REEs to metal is typically around <u>10%.</u>**

China produces close to 100% of the world's new* REE metal but is careful to assure that subcontractors to U.S. defense contractors (and others) have access to these base metals so they can produce "domestic" REE alloys and magnets.

Why? Because **10 USC 2533 b** defines strategic materials at the point of alloying and this allows the Pentagon to pretend that it has control over critical resources like rare earths.

# Tracing the Value of Neodymium From Mine to Magnet

+ Other REEs

# A Proposal on How to Build a Competitive & Resilient Value Chain

As outlined in S. 2093, H.R. 4410 and in a proposed Executive Order, the U.S. should establish a privately funded and operated multi-national Cooperative acting as a Rare Earth Value Chain for the production of separated oxides, metals, alloys, magnets and other value-added REE products.

The Cooperative would source REEs from any domestic producer and also utilize Actinide bearing REEs (at sub-market prices).

The Cooperative would act as “utility”, assuring the uninterruptable supply of value added REEs, such as metals, alloys and magnets, at the cost of production.

The Cooperative would pass on savings from its economies of scale and the use of Actinide bearing resources to the owners of the Cooperative and sell any surplus at ‘market pricing (to non-Cooperative owners)’.

# How Would the Cooperative Work ?

The Cooperative would use low-cost / high value thorium bearing REE byproducts from Phosphate producers as its primary feedstock.

- The Cooperative would provide low-cost tolling services to REE producers and other companies that chose not to join the Cooperative.

Thorium bearing resources would be managed, as outline in S. 2093 and H.R. 4410

- The thorium liability would be managed by a private corporation that would store the thorium in accordance with all state and federal regulations and develop industrial, medical and defense uses for thorium, including energy.

Anti-Trust exemptions allowed under the Cooperative structure would allow multi-national technology corporations and defense firms to invest in a single source producer of REE metals, alloys and magnets, thus maximizing scale.

# The Cooperative Structure | Uninterruptable & Economically Resilient

**The proposed REE supply chain is built on uninterruptable byproduct production:**

Not subject to Chinese price manipulation or other low cost producers
With no direct mining cost,
With much more valuable rare earth distribution values,
At potentially deep discounts to ‘market price’, and

**The cooperative structure also offers:**

The most economically stable business configuration,
The greatest potential for economies of scale, and
Lowest cost of finished REE product

Because of these and other reasons, the Cooperative can aggregate savings and pass them on to its owner/off-takers members in its metal, alloy and magnetic products and sell any surplus to non-members at ‘market price’.

## Final Note on MP/Molycorp Production Cost Claims:

Any cost advantage that MP claims it will inherit from the Molycorp process technology are long-gone, as both Molycorp and MP gave Chinese engineers unlimited access to the California processing facility.

Access began under Molycorp management and continued post bankruptcy.

## Other Sources:

Rare earth distributions for China and Myanmar were provided by Roskill.

> The Chinese distribution is based on averaging the distributions for all light REE producer (Byan Obo and others) and all heavy REEs producers (Ionic Clays) on a 50/50% basis.

Chinese costs are estimated to be 30% lower than U.S. producers:

> Sorce: Ryan Castilloux, Managing Director at Adamas Intelligence
>
> ***"Conservatively speaking, we estimate that the rare earth oxide production costs of China's largest producer, China Northern Rare Earth Group, are 25% to 35% lower than Australian incumbent Lynas due to economy of scale, access to low-priced feedstock and lower environmental costs."***