Seeking Alpha

Apple’s Dirty Little Rare Earth Secret

By Ben Kramer-Miller

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Summary

- Apple iPhones contain essential components that are enabled by rare earth elements.
- Some of these metals are produced exclusively in China, which means Apple is dependent on Chinese mining, processing and exports that are out of its control.
- There is a very real risk that Apple or its suppliers will not be able to get the REEs that they need - this could put the company's production at
- Chinese REE production causes environmental damage that contradicts Apple's "green" aspirations.
- Apple refuses to publicly acknowledge these issues, although as the world's largest company in terms of market capitalization, it should be held to the highest level of scrutiny.

Overview

Apple (NASDAQ:AAPL) shares have been touching all-time highs. Meanwhile, headlines lauding the company's achievement of topping a $700 billion market capitalization and analyst calls for a $150/share price have created the sort of euphoria that should concern contrarian investors. But what can go wrong? A survey of Seeking Alpha and other venues reveals that the

company could be vulnerable to competition from commodity-priced phones, computers and tablets, and that the strong dollar could create a headwind considering that the bulk of Apple sales come from overseas.

Bulls brush these aside, and rightly so. Virtually every company faces competition, and Apple has done a better job of handling this than most; and what's the big deal if Apple is earning fewer dollars if these dollars are gaining in value, and when any "losses" are offset by sales growth?

Yet, Apple is hardly a risk-free investment. As an investor in and writer on critical metals, I came across an article that reveals what I think is a potential threat to Apple. Apple products - and the iPhone in particular - contain very small amounts of, yet a wide variety of, rare earth elements: yttrium, lanthanum, cerium, praseodymium, neodymium, gadolinium, europium, terbium and dysprosium, according to the article.

The article is, in part, intended to promote the idea that America's only REE producer - Molycorp (NYSE:MCP) - is well positioned to benefit from rising iPhone sales. In fact, it is peppered with quotes from Molycorp's (then) CEO Mark Smith, including "Your iPhone doesn't work without rare earths in there." I will get to why this is the case below. But what the article doesn't mention is that most of Molycorp's production is from just two of these metals - cerium and lanthanum - and a small amount comes from two others - neodymium and praseodymium. The others - europium, gadolinium, terbium and dysprosium - are produced exclusively in China, with very minor exceptions.

This observation leads me to assert that Apple faces a low-probability yet potentially high-impact risk that it will not be able to produce iPhones (and

other products) - or more accurately that its suppliers will fail to meet its needs - in the event that China restricts its REE exports. Given that these elements are essential to producing Apple products, I believe that the bottleneck effect could be sizable and poses a risk to shareholders.

In addition to this risk to the Apple investment thesis, the company's "green" image is in jeopardy if consumers were to discover the extent of environmental impact that Chinese REE production really has.

In what follows I will show:

- That REEs, and in particular those produced exclusively in China, are essential to producing iPhones.
- Substitutability is at best a poor alternative that could be months or years into the future, and at worst impossible given the unique attributes of these metals.
- China controls virtually all production of these metals, and has actively pursued export restrictions that could seriously impact several of Apple's suppliers which operate outside of China.
- Chinese REE mines face virtually no environmental scrutiny, and have a negative environmental impact that runs counter to Apple's claim that it is a leader in the environmental movement.
- There is a very simple solution to these problems that Apple would have no trouble financing - the problem could be largely solved in just a few short years, at a minimal cost to shareholders.

1. What Makes REEs So Essential?

Going back to the Cnet article, you'll find that the above-mentioned REEs can be found throughout the iPhone.

- **The Color Screen**: Yttrium, lanthanum, praseodymium, europium, gadolinium, terbium, dysprosium. Some of these metals have no substitute in the color screen, such as terbium (green phosphors) and europium (red phosphors).
- **Glass Polishing**: Lanthanum, cerium, praseodymium. The iPhone needs polished glass, although these metals don't apply to the thesis at hand, since these metals are produced by Molycorp and Lynas Corp. (OTCQX:LYSDY) - the other major REE producer outside of China.
- **Phone Circuitry**: Lanthanum, praseodymium, neodymium, gadolinium, dysprosium. The circuits contain neodymium-iron-boron magnets that contain small amounts of dysprosium (and sometimes terbium, not mentioned by Cnet, although not necessarily found in iPhone circuitry) in order to stabilize their coercivity, which basically means that dysprosium is needed in order for the magnet to retain its magnetic quality at higher temperatures and to maintain stable properties through many cycles of heating and cooling. The neodymium-iron-boron magnet isn't essential, but the iPhone would be much bigger and less efficient without it.
- **Speakers**: Praseodymium neodymium, gadolinium, terbium, dysprosium. Speakers contain permanent magnets, and if you want that magnet to be small, it is going to be a neodymium-iron-boron magnet. If you want the magnet to function at higher temperatures, it needs to contain dysprosium and terbium.

- **Vibration Unit**: Neodymium, terbium, dysprosium. The same story applies. The vibration unit needs permanent magnets.

We've seen that there are five parts of the iPhone that contain REEs in some shape or form, and that in four of these five cases, the REE list includes at least one metal that is mined exclusively in China.

Now, of course, given what has been said, we can imagine a functional iPhone that doesn't contain certain REEs, and in the event of a shortage, the company could still make a phone. But clearly, it would be lacking. Let's look at a couple examples to see what the iPhone would be like without some of the key REEs.

1. **Europium**: Without Europium, the iPhone would not be able to display lifelike reds. There are worse things in the world, but Apple prides itself on its sleek and aesthetically pleasing products, which would make the situation unacceptable.
2. **Neodymium**: Neodymium is mined outside of China, but China remains the biggest supplier - and neodymium is essential for permanent magnets. Samarium-cobalt magnets are a possible substitute, but they are larger, less effective and cannot function in higher temperature scenarios the way neodymium-iron-boron magnets can (particularly with a dysprosium and/or terbium alloy). Without neodymium, your iPhone would be bigger and less efficient.
3. **Dysprosium**: Again dysprosium is essential for stabilizing the coercivity in neodymium-iron-boron magnets. While required only in small amounts (up to 3%), the phone would have to operate at lower

and more stable temperatures without dysprosium, and this would make it slower and less effective.

4. **Terbium**: Without terbium, the iPhone cannot display lifelike greens. Terbium also is a key ingredient in neodymium-iron-boron magnets, which, in small amounts (up to 0.5%), also increases the coercivity and potency of the magnet. Without terbium, the phone would be less efficient.

Could we have an iPhone without REEs, and in particular, the REEs produced exclusively in China? We could, but it wouldn't be able to display key colors (including a primary color), and it would be bigger and slower.

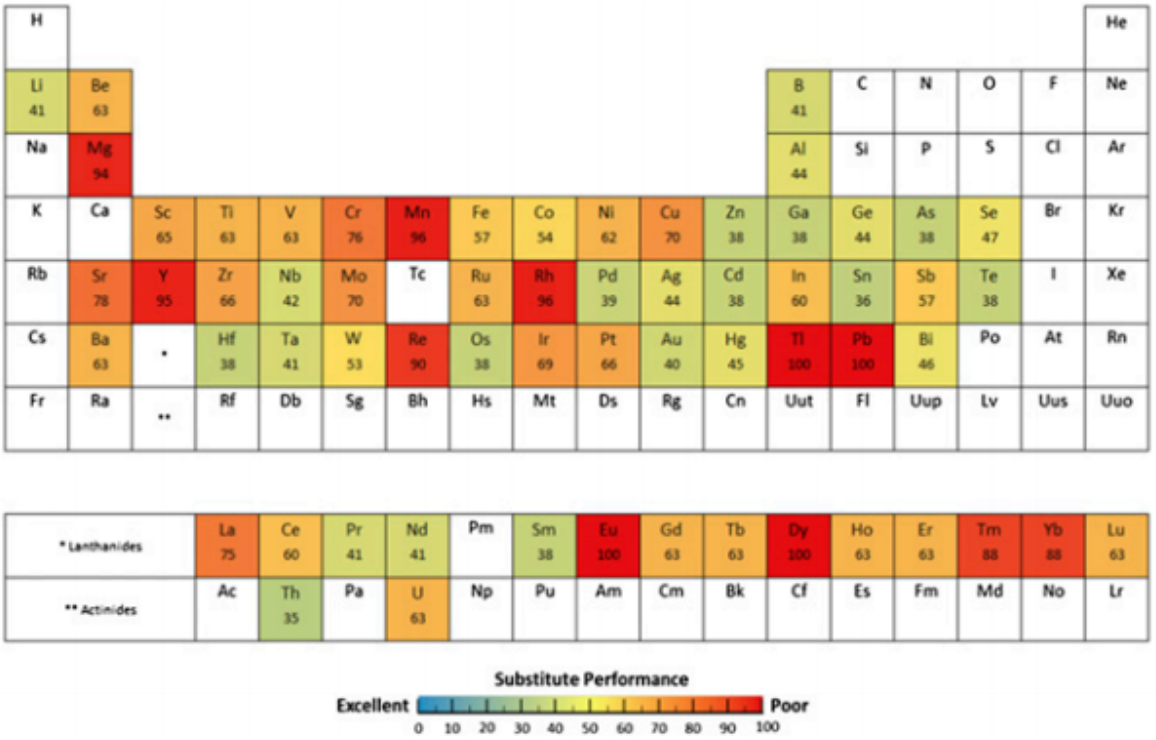
2. What About Substitution?

Now that we've established just how essential many of the REEs are in producing the iPhone, a counter-argument might go as follows: Apple has some of the most intelligent minds at its disposal, with access to billions of dollars. Why can't the company simply come up with a substitute for REEs?

The issue of substitutability has been studied extensively. While oftentimes there are substitutes for any given metal, rarely are they perfectly adequate - sacrifices must be made, such as an increase in cost, an increase in product size, or a decrease in functionality and efficiency.

T. E. Graedel discusses the issue in his "On the Materials Basis of Modern Society" (Graedel, 2013). He finds that substitutes are ineffective for many of the REEs found in the iPhone - dysprosium and europium, in particular. The following table illustrates the results of Graedel's findings.

(click to enlarge)



The data was arrived at by consulting with industry experts and compiling a list of the most common usages for each metal. While the approach couldn't be exhaustive, Graedel seeks to cover a minimum of 80% of the usage of each metal - this certainly includes phosphors and permanent magnets. Note that dysprosium and europium each received a score of "100," which makes them among the least substitutable metals.

One crucial thing to note regarding substitutability is that substitutes are often found among groups of metals, meaning that a likely candidate for an REE substitute would be another REE. The REEs as a group have similarities on an atomic level. The best substitutes for, say, dysprosium (and again this doesn't necessarily mean these are fully adequate substitutes) are going to be elements most similar to dysprosium, or closest to dysprosium on the

periodic table (e.g. terbium and holmium, the latter of which essentially has no market). Like dysprosium, these elements suffer from the same supply risks and are likely to be included in any export or use restrictions imposed by China that would impact dysprosium exports.

Given the situation, there are no options short of a new innovation. This is not impossible. For instance, neodymium-iron-boron magnets were mass produced by General Motors (NYSE:GM) in response to a cobalt shortage which forced the company to find a substitute for samarium-cobalt magnets. However, innovation takes time, and even a short-term export restriction or more general shortage can create the bottleneck effect that concerns me here.

3. China Controls The Production of REEs

China's control of the REE market is common knowledge in a precursory way, but I think many investors don't understand the extent of this or the implications.

A: Overview

China's dominance in the REE space didn't happen by chance. This has been a multi decade-long development, during which time China developed not just an REE industry, but an intellectual tradition that supports the industry that is conspicuously absent in the West. For instance, the Baotou Research Institute of Rare Earths has been around since 1963. By comparison, no such institutes exist in the U.S., and only recently have American policymakers begun to realize just how important this industry is and how far advanced the Chinese really are. But the intellectual interest in the U.S. is still largely from a policy standpoint rather than a scientific or an industrial

one, and this has ramifications that articles such as the above-cited Cnet piece simply don't capture.

For instance, the Cnet article discusses just how much REE mining takes place in China vs. the rest of the world, but it doesn't touch on the midstream/downstream advantages that the Chinese have developed. Not only does China produce >90% of REEs and ~100% of some of the most important REEs (e.g. dysprosium and terbium), but the Chinese have the technology to separate these metals from mined ore and to purify them beyond the capabilities of any non-Chinese nation. For instance, as of 2010, the Chinese could purify REEs to a purity of 99.9999%, whereas the Japanese could do so only to 99.99%. This has implications for Apple, which uses high-purity REEs. For instance, high-purity lanthanum, 99.999%, is used in optical glass formulations. The tiny lenses found on iPhones and other Apple products require in total a lot of high-purity lanthanum. While the lanthanum can be mind at Mountain Pass in California, it needs to be purified in China.

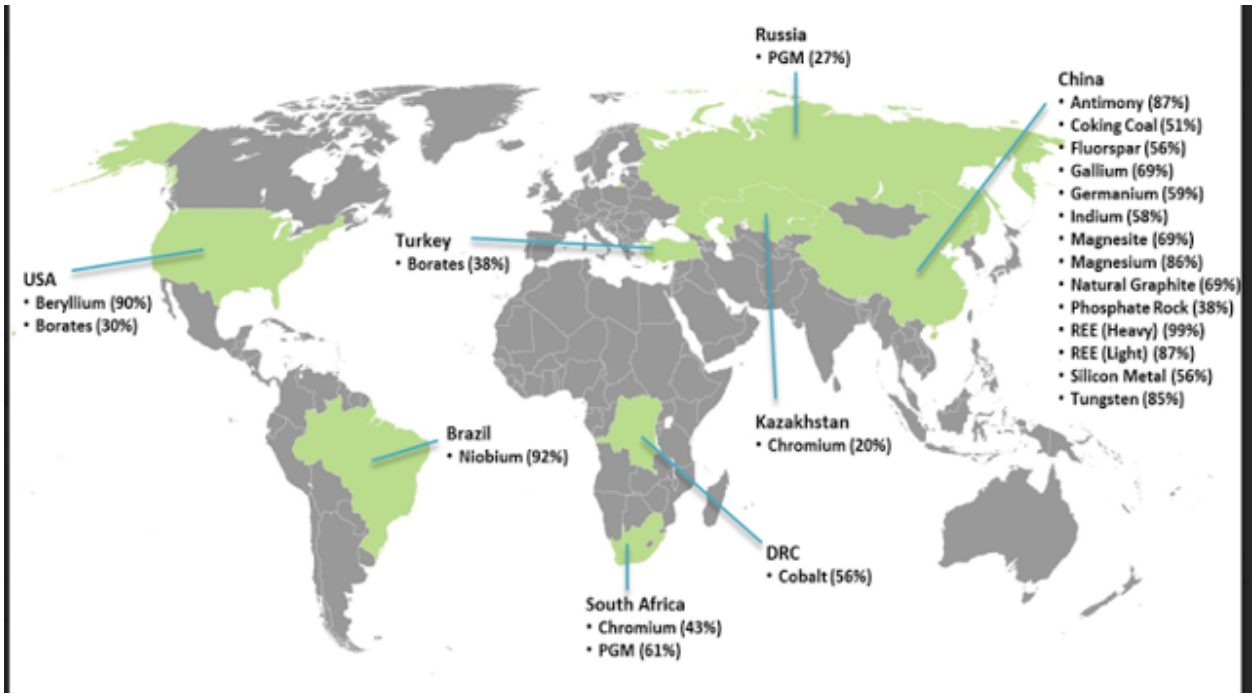
To this end, the fact that there is REE production outside of China is not sufficient to conclude that this production is an adequate solution to the REE problem. It also means that Apple can't simply stockpile REEs or order its component suppliers to do so while they are more or less readily available.

B: China's Dominance of HREE Mining

China does, in fact, produce ~90% of the world's REEs. But as I've hinted, this doesn't tell the entire story. REEs are divided into "lights" and "heavies" (LREEs and HREEs). The majority of REEs produced by Molycorp and Lynas are LREEs, and as a result, China's dominance in HREE production is far

more pronounced than its dominance in LREE production. The following visual from a European Commission Memo from May 2014 shows that China's LREE market share is 87%, while its HREE market share is 99%.

(click to enlarge)



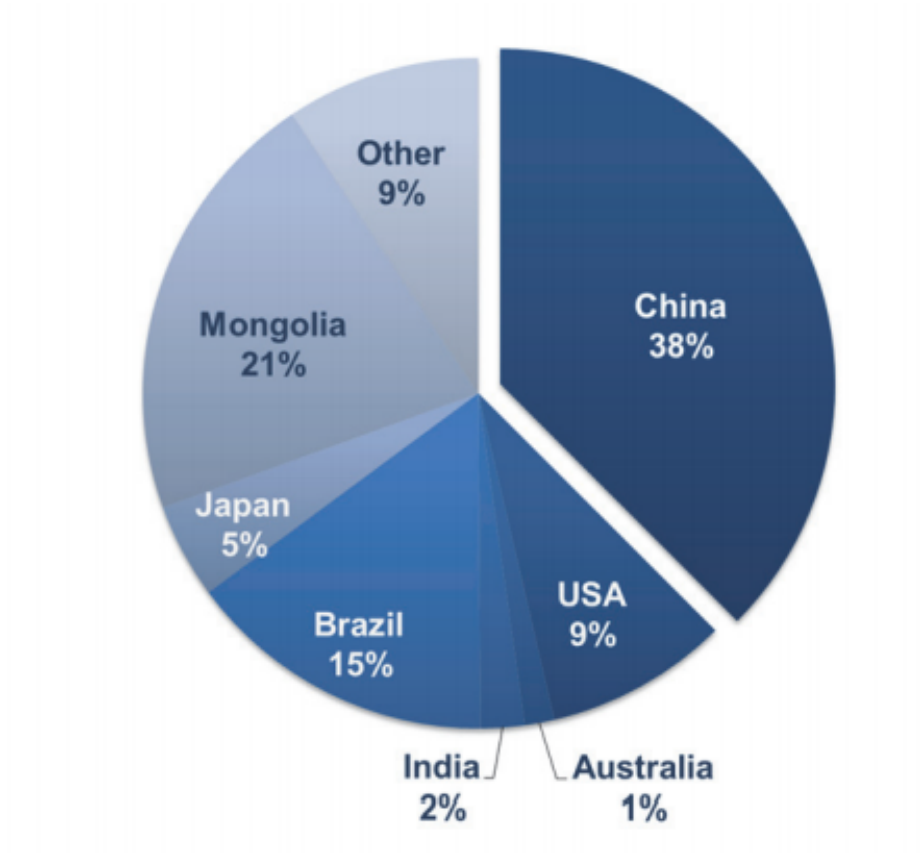
China's HREE dominance is unparalleled for any other industrial metal, even though the U.S. dominance in beryllium and Brazil's dominance in niobium come close.

But why should this matter, given that:

1. China may be a dominant producer of REEs, but it only holds ~38% of the world's reserves (with ~21% being in Mongolia) (see the following visual). While I don't have exact figures, there is no shortage of HREE reserves and resources outside of China, including plenty in the U.S.

2. China exports plenty of REEs and finished products, such as neodymium-iron-boron magnets.

FIGURE 2.1 – 2013 REEs GLOBAL RESERVES (147 MILLION TONNES)



Data: USGS (2014a) and Currie (2013b)

(Cf. *Critical Rare Earths, National Security, and U.S.-China Interactions: A Portfolio Approach to Dysprosium Policy Design* by David L. An, 2014)

Unfortunately, these points hardly address the root of the problem.

C. Ex. Chinese REE Reserves and Future Supply

While there are substantial REE and HREE reserves outside of China, the mining projects that have these reserves are all years away from production. Not only that, but there is no guarantee that these projects will move easily into the production stage. A brief overview of these companies will reveal that none of them is even close to or has an easy path toward production.

- Northern Minerals (OTC:NOURF, ASX: NTU) needs ~$314 million in initial capital to get its Browns Range Project into production. Meanwhile, it assumes that the price of dysprosium oxide (its primary product) is $724/kg, whereas the current price is closer to $400/kg.
- Great Western Minerals (OTCQX:GWMGF) is on the verge of bankruptcy, even though it has the most advanced dysprosium heavy project - Steenkampskraal - outside of China. If the company can avoid bankruptcy, it is probably the most likely to get into production first.
- Tasman Metals (NYSEMKT:TAS) recently put out a pre-feasibility study that shows it will need over $370 million in order to get its Norra Karr Project into production. Its assumed dysprosium oxide price is $575/kg., which is well above the current market price.
- Rare Element Resources (NYSEMKT:REE) is producing mostly LREEs, and its price assumptions for europium oxide ($948/kg) and dysprosium oxide ($655/kg) are substantially higher than market prices.

- Other promising companies with HREEs in their deposits, such as Ucore (OTCQX:UURAF) (Bokan) and Texas Rare Earth Resources (OTCQX:TRER) (Round Top), have yet to release feasibility studies.

Given current market conditions, I would be surprised if more than one or two of these companies got into production by 2018.

With this being the case, investors should expect the Chinese to continue to dominate the HREE mining space for years to come.

D. China Exports Plenty of REEs

China exports plenty of HREEs and finished products. Not only that, but a recent WTO ruling has led many to believe that the Chinese no longer have export quotas on REEs. According to a January 5th Bloomberg piece:

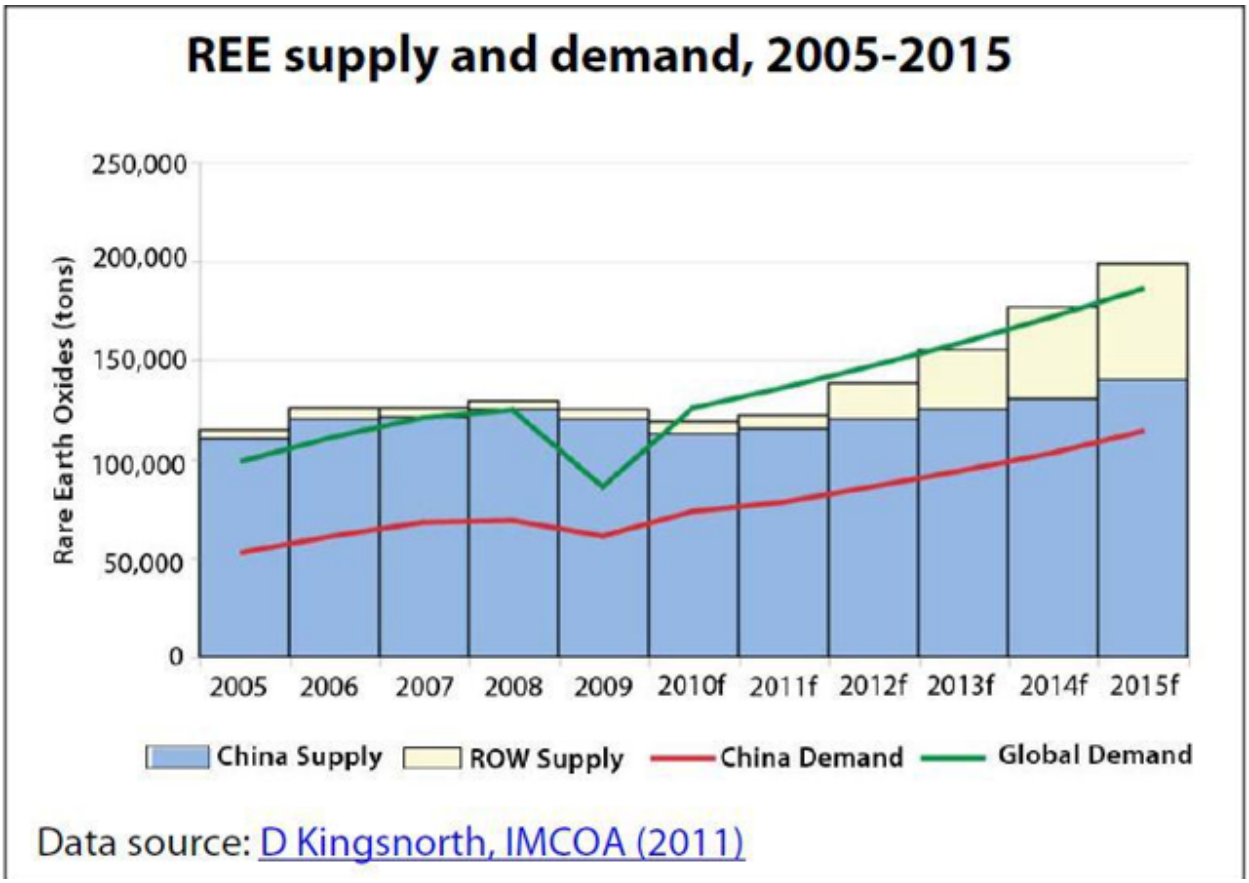
Rare earths were dropped from a list of products subject to export quotas, effective from this year, according to a Ministry of Commerce statement dated Dec. 31. Exporters now need only provide sales contracts to win export licenses. The move follows the WTO's rejection in August of China's appeal against an earlier ruling.

But those who are taking this to mean that the WTO has won in forcing China's hand in its REE export policy fail to understand the role that REE export quotas play in China's broader policy. Evidence of this can be seen in China's January REE export data, which shows that these exports fell nearly 50% from a year ago in CNY terms.

This situation was explained by REE expert Gareth Hatch, who points out the importance of export tariffs to China's overall policy designed to retain control of its REE industry. More critical metals (and we aren't just talking about REEs here) have higher export tariffs, and this evidently reflects China's motives.

Further, while the recent WTO ruling would suggest to the unsuspecting observer that China is gradually going to make its export policies more amenable to the West, the supply-demand fundamentals of REEs tell a different story. As the following chart illustrates, it has made sense for the Chinese to export some of its REEs, considering that its production outpaced its consumption.

(click to enlarge)

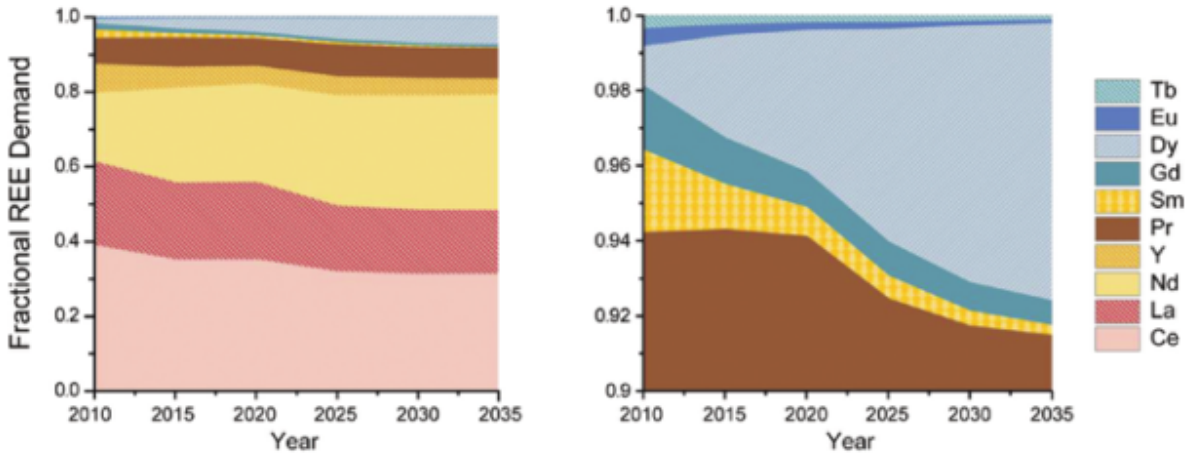


As you can see, however, Chinese consumption is approaching its level of consumption, and despite Kingsnorth's clout in the industry, this chart doesn't fully reflect the true nature of the situation, considering that a large part of this supply comes from cerium and lanthanum, which are oversupplied markets (most of the ROW supply you see is cerium and lanthanum).

To illustrate my point, let's look at the supply-demand fundamentals of what is arguably the most favorable REE from an investment standpoint - dysprosium - which we've seen is an essential input for numerous iPhone components. Research conducted by Elisa Alonzo et al. (2012) predicts that increases in dysprosium usage will far exceed that of other REEs. They

provide the following graphic, with the right-side zooming in on the upper part of the left side.

(click to enlarge)



Over the next 20 years, dysprosium demand is expected to grow at ~4 times the rate of the broader REE market. The Chinese know this, and have assigned a 25% export tariff to dysprosium.

Finally, it is worth noting that so far there have been no meaningful supply shortfalls in the space, and so the Chinese have had no reason not to comply with WTO mandates. But in discussions with Ucore's CEO Jim McKenzie, he revealed that several end-users stockpiled REEs back in late 2010-early 2011 when they feared that China really would restrict exports. This is what he believes led to the outsized price spike. He also suggested that one of the factors holding prices back despite rising demand has been that companies have been using these stockpiles rather than buying on the open market, and this is expected to end toward the end of this year.

The potential for demand to outpace supply in the near term could have the Chinese singing a different tune, especially for markets that it controls (e.g., they control 99.4% of the dysprosium market (An, D. L., 2014)).

With this in mind, Apple suppliers outside of China could find that they are no longer able to produce components that contain essential REEs, such as dysprosium, terbium and europium. The following is a partial list of suppliers that produce Apple components exclusively outside of China and make products that very likely contain the aforementioned REEs. Here is a link to Apple's complete supplier list for the reader's convenience.

1. AKM Semiconductor Inc. - Produces circuits sensors, magnets, compasses and LEDs. All of the former contain permanent magnets. LEDs contain phosphors which include yttrium, europium and terbium. Note that AKM does have a plant in Taiwan.
2. Analog Devices (NASDAQ:ADI) - Produces circuitry which contain dysprosium and terbium.
3. Avago Technologies (NASDAQ:AVGO) - Produces 3D touch sensors that contain magnets. The company also has numerous open-source patents, such as for its bulk accoustic wave resonator and its electroluminiscent materials for edge emittors, which definitely contain REEs.
4. Interflex Co. - Produces flexible printed circuit boards, which likely contain permanent magnets that use dysprosium and terbium.
5. Linear Technology (NASDAQ:LLTC) - Produces circuits which likely contain dysprosium and/or terbium, as well as neodymium.
6. Maxim Integrated Products (NASDAQ:MXIM) - Produces circuitry which contains dysprosium and terbium.

7. Skyworks Solutions (NASDAQ:SWKS) - Produces chips for mobile devices, which contain dysprosium and terbium in permanent magnets.

This list is hardly complete, but the point is made. Furthermore, it might seem that the real risk is in the businesses of Apple's suppliers. Don't get me wrong: these companies are at risk. But Apple depends on numerous suppliers to put together just one iPhone. In the event that these companies (or their suppliers in turn) cannot purchase REEs at all for reasons discussed above, they will no longer be able to supply Apple, and if Apple is unable to get even one component of the iPhone, it will not be able to produce and sell it. Since the company gets two-thirds of its revenues from the iPhone, this seemingly minor situation could prove to be deleterious to both Apple the company and its shareholders. At best, this situation would force one or more of the company's suppliers to relocate to China or for Apple to outsource the production of one or more of its components to one of its Chinese-based suppliers. This is a setback which would delay production for months, regardless of how much money Apple throws at the problem.

4. REE Production In China Causes Significant Environmental Damage

I've established that Apple products cannot function without Chinese-produced REEs, and that there is a very real risk that Apple and/or its suppliers will not be able to procure these elements.

But there is another elephant in the room, namely the environmental impact of REE production in China.

Apple prides itself on its environmental policy. Those who are concerned about the company's carbon footprint might easily be appeased by comments made on its environmental responsibility website. Apple claims "to work tirelessly to reduce (its) impact on climate change, find ways to use greener materials, and conserve the resources we all need to thrive." To illustrate its dedication to the environment, the company publishes the following graphic that shows how its computers have gradually reduced the amount of electricity they use in "sleep mode."

(click to enlarge)

The image gives the impression that Apple's developments over the years have led to a drastic reduction in the company's (and its customers') carbon footprint.

What it doesn't say, however, is that in order to reach these goals, Apple has had to use more REEs, which we've seen increases its products' efficiencies, while reducing their sizes. And the reductions shown in this

visual are countered by the tremendous environmental damage that Chinese REE mining causes.

Investors interested in this issue and China's REE industry more generally are encouraged to read Cindy Hurst's 2010 *China's Rare Earth Elements Industry: What Can The West Learn?* In it, you will find a short section entitled "Severe Environmental Damage." Hurst cites an article published by the Chinese Society of Rare Earths, which says that:

Every ton of rare earth produced, generates approximately 8.5 kg. of fluorine and 13 kg of dust; and using sulfuric acid high temperature calcination techniques to produce approximately one ton of calcinated rare earth ore generates 9,600 to 12,000 cubic meters of waste gas containing dust concentrate, hydrofluoric acid, sulfur dioxide, and sulfuric acid, approximately 75 cubic meters of acidic wastewater, and about one ton of radioactive waste residue.

She goes on to point out that:

- REE production contaminates waste water in a way that impacts farming and daily living.
- One ton of REE production leads to 2,000 tons of tailings (mine waste).
- Radioactive thorium is dumped into the Yellow River, which is a primary source of drinking water for 150 million people.

What are the Chinese doing about this? Effectively little to nothing. Chinese companies are not held accountable for the death of workers due to

environmental hazards the way Western companies are, so there is no incentive for the companies to make work environments safer and to prevent diseases such as pneumoconiosis (aka "black lung disease"). Furthermore, Chinese companies may officially be incentivized to clean up their act, but since they don't actually own the land (the government does), the fear of confiscation leads to the mentality that it is best to extract as much wealth out of the mine in as little time as possible.

This is a pretty bleak picture compared with the one Apple provides to its investors and customers, and the company policy seems to be "out of sight, out of mind."

5. What Can Apple Do?

Apple has a very easy solution to both the supply risk and its environmental problems: support North America's REE industry. As mentioned above, there are three "late-stage" companies that have the REEs in-ground to satisfy Apple's demand:

1. Rare Element Resources is mostly an LREE company, but it does have enough heavy REEs to satisfy Apple's demand. Its Bear Lodge Project is the most advanced of the three North American candidates discussed here.
2. Texas Rare Earth Resources has plenty of dysprosium, europium and terbium. It also has lithium, which is a key ingredient in Li-batteries found in Apple products.
3. Ucore Rare Metal's Bokan Project is small, but it has a high concentration of HREEs, and recent exploration results show that it is growing. Ucore also has government support, since its Bokan Project

has been deemed a "strategic American asset" by Senator Lisa Murkowski, and Ucore is in talks with AIDEA to receive Alaskan state funding to develop this project.

Should Apple support any one of these three companies, it would solve both of its problems. First, it would be able to source REEs from American sources, and it would not have to worry about Chinese export restrictions. Second, American environmental standards for mining are far superior to Chinese standards. Apple could, for instance, help these companies research tailings and radioactive thorium storage solutions in exchange for the right to buy certain REEs at a discount. This would expedite the permitting process for these companies. It also would mean that Apple would address the issue of its carbon footprint in China.

The Bottom Line

Given what I've said, I think it is evident that:

1. Apple needs REEs.
2. Apple or its suppliers outside of China may not be able to get REEs.
3. This could have a serious impact on Apple's production, its revenue, and ultimately its share price.
4. Apple is either ignorant of or is ignoring its carbon footprint related to its exposure to REE production in China.
5. Apple has a very simple solution, namely it can support North America's REE industry.

Of course, one could make this claim for all sorts of companies, from Intel (NASDAQ:INTC) to Hewlett-Packard (NYSE:HPQ) to Tesla (NASDAQ:TSLA). So why pick Apple?

Apple is the most valuable and the most widely followed company in the world. I believe that (1) the company needs to be held to a higher standard and needs to be able to withstand greater criticism than its peers, and (2) the issue of China's dominance in the REE space is one that is not widely known, and by exposing Apple's vulnerability, I hope that we will begin to see American companies get in front of what could be a serious problem.

Apple seems to be unprepared for what could be a blow to its production line. In researching this article, I was not able to find evidence that the company has taken a meaningful step to either procure an REE stockpile, have its suppliers procure an REE stockpile or secure an REE supply for itself or its suppliers in any way. Furthermore, when I contacted Apple's investor relations staff regarding the matter, I was sent two documents. The first was on Apple's policy on conflict minerals, which is unrelated to my concern. The second was Apple's Supplier Responsibility Report, which discusses how Apple makes sure that its suppliers treat their workers well and minimize their respective environmental impacts without any reference to REEs.

In other words, they either don't know that there is a problem or they refuse to acknowledge that they have one. Either way, I see this as a problem for Apple investors and for others who share my concern that American companies may not have the access to REEs that they need.

With that being said, this is by no means a "sell" recommendation for Apple shares. Apple continues to produce more of the products that have made it

the largest company in the world. I haven't done an in-depth valuation analysis or my own assessment of Apple's competition, but the company has time and again outperformed its competitors, while its shares seem to trade at a reasonable valuation at just ~12X last year's operating cash flow.

However, analysts seem to be focused on a couple of risk factors, such as competition, forex issues, margins... etc., when something as simple as Apple's ability to actually make the iPhone is taken for granted. While there is no evidence that Apple can't make the iPhone or that it won't be able to, I think I have demonstrated that this is a legitimate risk factor that flies under the radar due to its simplicity. I also think this risk is sufficiently actionable for those Apple investors who wish to mitigate this risk, even if it is on a very small scale.

What can investors do? First, limit the size of your Apple position. Furthermore, reapply the analysis I carried out here with other investments. As an investor, you always want to find ways to diversify your risk, but you can't do that if you don't know what these risks are. After reading this, you may find that 75% of the your portfolio consists of investments that would suffer in the event that China significantly restricts its REE exports. Unfortunately, you'll find that REEs are found in just about every high-tech gadget. You'll find that defense contractors, medical device producers and oil service companies all have some exposure to the risks discussed in this article.

Second, you could "hedge" your position by investing in an REE junior mining company. This is easier said than done, because these are extremely high-risk investments. As we saw above, all of the more advanced REE junior mining companies face difficulties going forward. But with that being

said, the kind of announcement that creates the effect that I discuss above would be the same kind of announcement that would send shares of most, if not all, REE junior miners soaring hundreds, if not thousands of percentage points.

But with that in mind, investors need to be acutely aware of the risks of investing in the junior REE miners mentioned above.

- Only Great Western Minerals has revenue, because it owns an alloy-producing subsidiary called Less Common Metals. The company also has a lot of debt, and there is a good chance that it will go bankrupt. Investors should avoid this stock. Otherwise, none of these companies have any current revenue, and revenue is going to be years away for some of these companies. The others will never see revenue.
- In order to get into production, these companies need far more money than they can feasibly raise without substantially diluting shareholders.
- Only Rare Element Resources has a sizable capital position (relatively speaking). As these companies de-risk in preparation for financing and construction their projects, they will likely need to raise capital, which means they will dilute shareholders.
- Only Tasman Metals and Rare Element Resources trade on major exchanges in the U.S. The others, except for Texas Rare Earth Resources and Northern Minerals, trade on the Toronto Venture exchange. Texas Rare Earth Resources trades over the counter, although it does file with the SEC. Northern Minerals trades on the

Australian Stock Exchange. Many of these issues are illiquid and inappropriate for most investors except as small positions.

- Mining is a volatile business with variable operating costs, unforeseen events impacting operations, and constantly fluctuating metal prices.

That being said, I have established that REEs are essential and that the West needs an ex-China REE supply, and this supply will come from a subset of the companies mentioned here.

So if you own 100 shares of Apple, sell 5 and buy an REE junior or two. This is not the venue to discuss which companies to invest in, but my favorite is Texas Rare Earth Resources. You can read my interview with the company's Chairman Anthony Marchese here. Since that interview, the company released the highlights of a mine-size reduction plan, and announced progress in separating out impurities from its REE-rich ore. Note, however, that this is a company with a ~$9 million market capitalization that doesn't trade on any major global exchange. While I think this is in part a reason for the opportunity, this stock is certainly not for everybody, especially for investors used to buying large-cap technology companies.

The lowest-risk company in the space is probably Northern Minerals, given how advanced it is and its unparalleled exposure to dysprosium. However, it is by far the most expensive, and it really doesn't trade on the OTC market - you need to buy it on the Australian Stock Exchange.

Third, Apple investors need to pressure the company to publicly address these issues. One inquiry and one article probably won't force Apple's hand,

but 1,000 inquiries and more articles like this one will get Apple's attention and put the company in a position where it has no choice but to come out with a plan that addresses its REE-exposure.

Afterthought

I think when investors look at a company such as Apple, they see a substantial revenue stream, wide margins, an economic moat and a strong balance sheet that all point to the conclusion that the company isn't just a good investment, but that it is shielded from risk. This is the case because investors often think of risk in financial terms (so a company with weak margins or losses and a poor balance sheet is "risky"). That is certainly true, and I think this is why a lot of investors like large companies such as Apple.

But what investors don't seem to take into consideration is just how fragile Apple is, considering that it is dependent on literally hundreds of suppliers, which in turn, have their own suppliers and so forth. If any one of these suppliers can't meet its obligations, this goes all the way up to Apple, and if this failure is of the right kind (magnitude may not even matter), then Apple may not be able to deliver one of its products for a short period of time. This massive chain of dependencies, along with the fact that Apple's products share similar components (after all, for instance, the iPad is really just a big iPhone with a few modifications) suggests to me that Apple is quite fragile, and that numerous things can go wrong that aren't immediately apparent, because the problem can start out small and grow before it is too late.

In this article, I pointed out one way in which this could happen, and I think it is important that Apple investors are aware of the fact that the company uses these REEs that may not be accessible. But it is probably more

important for Apple investors to recognize that the company's complex network of suppliers (which, in turn, have their own suppliers) is actually quite a sizable risk - and the more links there are in the numerous chains, the greater the risk.