Magnets will Show Us the Way

- **“Cheap and Cheerful” not Enough**: In some of our past work, while rare earth prices were high and financial investors were interested, we conjectured the first success stories in the REE space would be relatively inexpensive and economically viable projects, regardless of their mine life. That is unlikely, given the capital market’s lack of interest in resources. If strategic investors are going to become interested, they need projects to meet certain criteria, and those criteria are much more stringent than being inexpensive.

- **Magnets and more Magnets**: The main driver for any level of interest will be, we believe, magnet materials. Specifically, unless a project will produce meaningful levels of neodymium/praseodymium and/or dysprosium, it will probably not matter.

- **Passing Muster**: Our criteria for selection of these “strategic grade” projects doesn’t leave too many projects standing, but we truly don’t need many, anyway. This list includes Molycorp (MCP-US) and Lynas (LYC-ASX), two current producing projects, along with Arafura (ARU-ASX), Rare Element Resources (RES-US) and Quest Rare Metals (QRM-TSX). There are perhaps a few names that deserve honorable mentions, in that they are only eliminated from discussion on the grounds of more subjective criteria, but the above serves as a reasonable starting point.

- **Supplies and Prices**: With the above five names providing supply into the rest-of-world market for rare earths, we anticipate that by 2020 prices will allow for a reasonable profit to be made by all the names. And even more importantly, we have developed a “pessimistic” or “worst-case” price deck, against which all of the companies listed above would at least survive. Against this supply backdrop, we have produced our “base-case” REO price deck, through 2025.
The Recent History of REEs

The rare earth industry outside of China is nothing if not changeable. Both Molycorp (MCP-NYSE) and Lynas (LYC-ASX) have been unable to generate profits, and both have been hamstrung in doing so by a combination of ongoing technical issues that have affected their plant operations and production ramp, along with a market that is struggling to recover from the price shocks imposed on it by the sudden imposition of stringent Chinese export quotas in mid-2010. While Molycorp management has been adamant that the market for physical rare earths is becoming stronger, that the company is “selling every molecule” it makes, the movement of market capitalizations for companies in the space have suggested that institutional financial investors have abandoned the rare earth space. But in order to encourage the recovery of demand outside of China, it will be necessary to provide sufficient material to end users. This will only happen if additional financing to build new mines is available, because the output from Lynas and Molycorp alone is likely insufficient and is insufficient, in our view, to guarantee the necessary engineered products for end-users, particularly for users of high-strength magnets.

At the same time, however, end users of rare earths have not changed their opinions regarding rare earths. Indeed, across the board, whether the commodity under discussion is graphite, rare earths or any other Chinese-dominated commodity, the opinion of end-users is that they must diversify away from Chinese supply. This opinion is driven by two main factors. One is the willingness of the Chinese ministries to restrict supply of materials through direct action, such as imposing export quotas on rare earths or tungsten. The other is the increasing concern in China with respect to environmental damage, and the lax environmental controls in place at existing suppliers in China, exemplified by a major rare earth supplier such as Inner Mongolia Baotou Steel Rare-Earth Hi-Tech Co. (600111-Shanghai) suffering a delayed export approval due to environmental lapses some time ago and the temporary closure of various suppliers of natural flake graphite and related products to improve environmental practices in Heilongjiang province this year. End-users require reliable supply of critical materials, and policies that restrict such access, or that risk suppliers being shut down without warning, cannot be tolerated.

In the case of rare earths, there are specific issues that pertain. There are few automotive engineers that would debate this, outside of perhaps the engineers at Tesla Motors (TSLA-NASDAQ), but in both hybrid and fully electric automobiles it is a permanent magnet synchronous motor (PMSM) using rare earth-based permanent magnets that provides the most efficient and most cost-effective solution within a drive train. We will not reopen this debate, if the reader is
curious there are a number of publications from SAE International (previously known as the Society of Automotive Engineers) that outline the reasons why PMSMs incorporating neodymium iron boron (NdFeB) magnets support lower operating and capital costs in vehicles. There is no good alternative option to direct-drive generators incorporating NdFeB magnets in very large off-shore wind turbines, due to the enhanced reliability and increased efficiency of a direct-drive generator incorporating very large permanent magnets over a conventional generator with a mechanical transmission. It is impossible for motors using induction designs or ferrite magnets to be as small and light as a motor using rare earth magnets in aerospace applications. It is clear that there is an ongoing need for rare earths in the automotive, wind power and aerospace industries.

At the same time, however, neither of the current ex-China producers of rare earths, Molycorp nor Lynas, is able to produce a substantial quantity of dysprosium (Dy). The Achilles’ heel of NdFeB magnets is that while they are capable of producing intense magnetic fields, enabling very small and very high power motors, those same magnets are susceptible to de-magnetization if their temperature rises too high in those same high power applications. Dysprosium acts to counter this effect, allowing a much higher operating temperature before de-magnetization can occur, or even have an appreciable impact during operation. While there are various physical processes that can produce NdFeB magnets that are more resistant to de-magnetization without using dysprosium, none of them have the history or the industry acceptance of using dysprosium.

We have previously described (in publications issued while we were at Byron Capital Markets, as well as in less formal conference presentations and Internet postings) why we believe that, as dysprosium use declines as a percentage component of NdFeB magnets and helps to bring down the cost of NdFeB magnets, volume growth in the magnets will climb higher. In order to ensure reliable supply of these magnets, users outside of China will need to be able to buy from new suppliers of magnet materials.

By our argument, above, automotive companies such as Ford (F-NYSE), Nissan (7201-Tokyo), General Motors (GM-NYSE) and their various motor or magnet suppliers would be supportive of the construction of new rare earth mines outside of China. So, too, should wind turbine suppliers such as Gamesa (GAM-Madrid), Siemens (SIE-XE) and General Electric (GE-NYSE). Even aerospace companies such as Boeing (BA-NYSE) and Lockheed Martin (LMT-NYSE) and their motor suppliers such as Thales (HO-FP) or Eaton (ETN-NYSE) should be concerned about reliable and cost-effective supplies of rare earths outside of Chinese ministry control.
Thus, to our way of thinking, the argument as to what types of rare earth projects may come to market has shifted. In 2010 and 2011, our argument went that financial investors would likely support the “cheap and cheerful” rare earth project. This was our description for a project that required no more than a few hundred million dollars in capital expenditure, and that could be brought to market relatively quickly, in no more than four years. However, the rapid avoidance of high-priced rare earths by industry (both outside AND inside China, to be fair) led to rapidly declining prices and a complete loss of interest on the part of investors. And that means that the only immediate support for rare earth projects will be motivated by strategy, most especially from end-users.

If true, then the requirements of strategic users should dominate the discussion of what projects will garner support and survive. These requirements form the backbone of project selection by groups like the German Rohstoffallianz, the collection of German companies seeking security of supply for selected critical materials. This list, we believe, includes such factors as the ability of a project to supply for a very long period of time, a requisite high level of geopolitical stability of the nation in which the project is located, and economic viability of the project, among a number of other factors. When major corporations are allocating support for a project, whether that project costs $300 million or $600 million to build is less a concern than whether the operating costs provide for a potential 5% or 50% margin.

Future Pricing of REOs

Our previous “pessimistic” rare earth price deck, which was discussed in various forums including the blog InvestorIntel, was designed to answer a simple question asked of us by institutional investors. That is, how bad can rare earth prices get? By and large, institutional investors do not have the time to devote to deep inspection of commodities with small markets. These fund managers can be forgiven for thinking that, given the precipitous fall in rare earth prices since late 2011, rare earth prices might be headed to zero. Our “pessimistic” price deck looked to a rather unlikely combination of circumstances, that sufficient financial backing was available to build enough new production capacity to satiate demand in almost all rare earth markets. This resulted in rather low prices, especially in the interim period from 2015-2019, through to 2025. In spite of this, however, more than a few projects continued to generate positive cash flows and would survive. However, if additional major suppliers entered the market, we showed that prices would be depressed to the point that some suppliers would be forced to exit the market. This is truly “as bad as it can get”.
However, the actual situation today is very different from the one we assumed in formulating this pessimistic scenario. It is unlikely that any rare earth project will be funded by pure financial investors. Instead, it seems logical to us that a small number of rare earth projects will be supported by strategic investors, most especially end-users. These same projects will in turn be supported by lenders and perhaps a few financial investors who have taken the time to understand the rare earth market. This is likely to result in a much smaller volume of new supply entering the market through the study period.

To try and better understand what projects fit the criteria of strategic supporters, we began with a database that included 38 later-stage rare earth projects. We then applied cuts to the data that included the following:

- Project is capable of commencing DFS and permitting by end of 2015 (20 projects remaining)
- Project is located in a nation with essentially zero geopolitical risk (14 projects remaining)
- Project has a resource and planned output that supports at least 20 years of production (11 projects remaining)
- Project must produce at least 2,000 tpa of NdPr oxide OR 250 tpa of Dy oxide (9 projects remaining)
- Project must be cash flow positive using our “pessimistic” price deck (7 projects remaining)
Project must have minimal technical and/or social acceptance risks remaining; production should be from previously processed minerals in minimally populated mining regions.

The output of this model consists of only five projects, and two of those are already in production. The group includes both the Mt. Weld CLD and Duncan deposits belonging to Lynas, and Molycorp’s Mountain Pass. In addition to these producing projects, Arafura Resources (ARU-ASX) of Australia and Rare Element Resources (RES-TSX, REE-US) of the United States are predominantly LREO developers that make the cut. On the HREO production side, Quest Rare Metals (QRM-TSX) of Canada is the only project that satisfies all our criteria.

Yes, we fully agree that there are many other rare earth projects under examination, albeit far fewer are in active development than was true in 2010 and 2011. However, many of these projects are in geopolitical regions that render them of minimal interest to strategic supporters, or they have social acceptance or technical risks attached to them. While some would argue the degree of that risk in supporting their own personal favorites, we would argue that there is no shortage of good projects available for development and if there is no good reason to take on ANY such risk then we do not believe that a strategic investor such as a corporate end-user will do so.

We maintain the same latent demand models (that is, demand for a commodity or product at reasonable and economic price points) as we have previously used for our “pessimistic” rare earth price deck. There is, of course, a potential level of demand, and a maximum price beyond which substitution pressures take hold, for each use of rare earth in a variety of different industries. For specific rare earths, there may be multiple industrial segments that can use them, each with a different substitution price. For example, to take an extreme case, the latent demand for lutetium (Lu), used in medical scanners, is effectively infinite compared to present or even future production and we would expect to see prices remaining roughly at these historically high levels. However, the price of substitution of neodymium (Nd) and praseodymium (Pr) for magnets used in direct drive wind power generators is likely less than $200 per kg, even though latent demand below this price may grow to be very large. To fully realize such latent demand for REOs, prices must remain below the price point encouraging substitution and supply reliability must be sufficiently strong.
Our assumption is that only Molycorp, Lynas and three other potential suppliers will enter the market. Each commences production in the year suggested by the individual company, but we build in a two year production ramp to nameplate capacity for each project. This lower level of supply strongly suggests that we will see higher prices for rare earths in the mid-term than were indicated in the above “pessimistic” price deck. The relevant supply projections for the individual rare earths are shown below:

**Exhibit 3 – REO Supply from RoW Sources by Element and Year**

Source: Stormcrow
We utilize the same types of pricing models as previously used to derive our pessimistic price deck. These models are non-linear and of the form:

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Price = \frac{A}{B + Supply\ Excess}
\]

where A and B are constants, determined using a least squares methodology. In some cases, a constraint must be placed on the value of B (so that B is suitably larger than a negative value for Supply Excess, indicating an ongoing potential supply shortfall). Supply excess is the supply of a particular rare earth oxide (REO) in a given year as produced outside China, plus estimated pirate production from China, plus a fraction of Chinese supply, less latent demand. Our estimate of the level of Chinese REO pirate production is between 10,000 and 20,000 tonnes per year, declining with time and largely from south China, and the appropriate fraction of Chinese licensed production that will be relied on by ex-China buyers is fitted to historical demand data (2010-2013) using a statistical technique.

The one exception to the above methodology involves pricing for lutetium. Lu is primarily used in the manufacture of detector crystals for positron emission tomography-type medical scanners. There are other types of detector crystals that can be used, but lutetium orthosilicate crystals provide the highest sensitivity and resolution, meaning that scans can be completed faster and in greater detail. The faster speed means that PET scanners built using Lu-based crystals can generate more revenue for a hospital or clinic. We believe that the price point for Lu oxide above which substitution becomes a factor is roughly $1,250 per kg, so we maintain this price moving forward as demand is significantly greater than world levels of production.

Our Base-Case REO Price Deck to 2025

The results of fitting the above data for each relevant REO to historical annual pricing data obtained from *Asian Metal* for the period 2009 to 2013 (where available) is given below. Exhibit 4 represents what we feel is our best estimate today for the likely state of REO pricing through 2025:

*(table follows on next page)*
The above prices take into account the lack of general financial investor interest in the rare earth industry, following the disappointing financial results from Molycorp and Lynas, and the widespread downturn in all other junior company share prices. Our “base-case” price deck suggests that sufficient support for only three additional rare earth mines would result in prices that are reasonably high compared to historical norms, and that could provide very reasonable financial returns for all the companies involved.

Source: Stormcrow

The present lack of interest in the rare earth market by general financial investors is, unfortunately, warranted. Molycorp and Lynas have, to date, demonstrated no ability to generate profits, and, in fact, are both suffering from continuing technical and market challenges. However, there are groups of end users of rare earths that recognize the need for additional projects outside of China, especially those projects capable of producing large quantities of magnet materials such as neodymium, praseodymium and dysprosium.

We believe that the list of potential new rare earth mines contains a few projects that meet a stringent set of criteria including long mine life, geopolitical stability, high annual production of critical rare earths, economic viability and low technical and social acceptability risk. In fact, apart from the mines and chemical operations presently belonging to Molycorp and Lynas, both of which we believe will be in production for many years regardless of who ultimately owns them, only three projects fully meet those requirements.

If we assume that the producing rare earth mines outside of China eventually belong to Molycorp, Lynas, Arafura, Rare Element and Quest, and that each project enters the market on the timetable set by the individual companies, then
we believe that prices will adjust according to our Exhibit 4, above. These prices allow for reasonable profits to be generated by all of the producers.

We believe that this price deck represents a reasonable base-case scenario for rare earth companies. For rare earth junior companies wishing to use a price deck to analyze their prospects, it is important to note that the entry of even a small producer into the market can skew subsequent pricing considerably. We would suggest using our “pessimistic” price deck to evaluate whether a prospective project is economically viable under a worst-case scenario. However, the above “base-case” analysis only pertains to the production volumes we have outlined, and any additional production that is introduced would depress pricing further from these levels. In other words, it is incorrect to assume that these prices will hold if another project enters the market, because the RoW production level assumed in this analysis is only 81,000 tonnes per year by 2020, and much of this is cerium (Ce) and lanthanum (La). The rare earth market is unlike the copper or gold markets, where additional reasonable levels of supply are incapable of perturbing pricing. It is only our “pessimistic” price deck that describes something of a floor.

While most financial investors have chosen to ignore rare earth companies at present, we believe strategic parties remain interested in the space. They are interested in a very select few of the large number of prospective projects available. Those projects can likely generate robust profits for investors that understand the rare earth market well enough to apply proper discrimination.
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industry

relevant companies

why do we use keywords?

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