

Jack Lifton on Rare Earth Supply Chains and Value Chains

Rare earth sector analysts have finally recognized that a project's place in a total supply chain is very important to its economic viability. Before a junior mining deposit goes into (usually expensive and time consuming) development into a producing mine there must first be an evaluation of what possible product(s) of that mine are demanded by the next step in the supply chain and what price(s) they may bring when the mine begins production. Most such evaluations are at best extrapolation and at worst pure speculation due to unpredictable commodity price cycles. Even for producing mines like MP Materials Corp. (NYSE: MP) and Lynas Rare Earths Limited (ASX: LYC) their places in the total supply chain differentiates them from each other because of the different value of their current respective delivered products.

The sale of rare earth permanent magnets brings a majority of the revenue in the total rare earth products supply chain. But no non-Chinese company has ever been vertically integrated from a mine to a magnet maker. The closest that a Western owned company (Canadian) has come to being a total rare earth permanent magnet supplier is Neo Performance Materials Inc. (TSX: NEO), which has everything (in the total rare earth permanent magnet supply chain) but a mine. Neo Performance sells rare earth products (oxides and chemicals) as well as rare earth enabled products (e.g., magnets) and has been consistently profitable with revenues exceeding \$500,000,000 per year. This year, 2021, Neo will shortly begin taking delivery from America's Energy Fuels Inc. (NYSE American: UUUU | TSX: EFR) of 70 tons per month of clean mixed rare earth carbonates (MREC) extracted from domestic American monazite. Energy Fuels is the first American company to produce rare

earth concentrates free of radioactive elements and interfering ions in at least 25 years. The MREC can be put into solution directly at Neo's European rare earth separation plant and fed into the system as a pregnant leach solution (PLS). Thus, Neo Performance can deliver to its customers downstream products, such as separated oxides, metals and magnet alloy powders and bonded magnets (made at its Thailand operations) that are produced by a total rare earth supply chain with no Chinese involvement.

Energy Fuels reports that its monazite extraction/purification system to produce clean MRECs is profitable. MP says that its bastnaesite ore concentrates now sold exclusively to China's Shenghe Resources are profitable. Lynas says that its in-house separated rare earth oxides are sold at a profit. For rare earth juniors, the successful (I.e., profitable) sale of ore or clean mixed rare earth carbonates is the key metric and few of them succeed.

The total rare earths' (enabled products) supply chain has the following composition:

1. Mining,
2. Extraction of the rare earths from the mining concentrates and the preparation of a clean, pre-PLS, mixed rare earths product,
3. Separation of the mixed rare earths into individual oxides and blends,
4. Manufacturing of chemical products, such as phosphors and catalysts, and of individual metals and alloys forms, and
5. Manufacturing of rare earth permanent magnets from rare earth alloys.

Historically mining companies have done steps 1,2, and sometimes 3, while specialized smaller companies have done steps 4 and 5 as separate ventures.

The rare earths' value chain is not the same as the supply chain. It is very difficult to make money mining, extracting, or even separating mixed rare earths into individual rare earths and blends. Lynas, for example, has become profitable by reducing the costs of separation to where they are comparable to those of the Chinese. Lynas' monazite ore body is much richer than, for example, MP's bastnaesite or even that of China's Bayan Obo. Lynas is now profitable selling individual rare earth salts and blends, but it has taken a decade and \$2 billion to reach this point, and the company's survival was actually due to long term low interest loans from a Japanese government agency designed solely to give Japan a backup to Chinese sourcing.

MP Materials is today only an ore concentrate producer, and its original capital needs were only to re-open a relatively recently closed large-scale well-run mining and ore concentrating operation. MP basically acquired some \$2 billion of sunk costs for about 1% of that. The real challenge now is for MP to (attempt to) match the Lynas model, and deliver separated rare earths and blends just as the original Molycorp did until 20 years ago. I am told that Molycorp II's Project Phoenix ran first just before the bankruptcy, but I only get silence when I ask if it was running economically and efficiently. I am very skeptical about MP's announcements that they will be separating rare earths at Mountain Pass in 2022 if by that they mean economically and efficiently.

Lynas has never advanced beyond separation in the supply chain, and I have never heard it said that they plan to do that or want to do it. The Lynas 22,500 tpa operation in Kuantan, Malaysia, took seven years and \$1.3 billion to begin commercial operation, and it is limited to processing monazite to extract and separate light rare earths only. If Lynas chooses to build a light rare earths separation plant in the USA as has been announced I suspect it will take 2 to 3 years to build and burn-in and that if it is to be a 5000 tpa system

as announced, and that it will cost far more than \$60 million on a greenfield site in Texas.

Project Phoenix was to be a 20,000 tpa system. It never ran commercially even though well over a billion dollars was expended on it over a four-year period. It is extremely unlikely that Project Phoenix can be resuscitated and brought into profitable operation in just one year, if ever.

Molycorp II, in its attempt to vertically integrate bought the rare earth permanent magnet alloy making operations of Santoku, America, in suburban Phoenix, Az. In 2011 for \$17 million. Within two years the operations were shut down as the necessity to buy Chinese metal as feedstock made profitability impossible.

Energy Fuels is buying monazite concentrates and removing the uranium and thorium as well as non rare earth elements in its existing White Mesa uranium mill in Utah. Less than \$2 million was needed in additional equipment to give the mill the capacity to process 2500 tpa of monazite to recover the contained 55% of total rare earths.

Neo Performance can distribute costs across its almost total in-house supply chain. It can thus maximize profits in its highest margin end-use products. MP is literally a start-up beyond the mine, and the jury is out on its potential for success. Lynas' operations were designed by former Solvay chemical engineering managers with the longest continuous experience in rare earth separation in the world. The chemistry chosen for Kuantan was that proven by experience and use by Solvay, China. Neo Performance Materials is the successor in interest to Neo Materials, which was founded in the 1990s and is helmed today by one of its original founders. Neo Materials perfected the bonded rare earth permanent magnet and is today the supplier of 80% of the world's supply of them.

Energy Fuels has been in business since the late 1980s, and is America's sole licensed uranium mill and thorium storage site. From the inception of the plan to process monazite until commercial operations took just one year. Uranium is purified by solvent extraction, and Energy Fuels has more than 500 man-years of experience with solvent extraction. The company is doing a scoping study on a dedicated rare earths solvent extraction system and has been awarded a contract by the US Dept of Energy to study the separation of rare earths derived from coal and phosphate-acid residues.

MP and Lynas are the largest, rare earth miners outside of China. Lynas and Neo Performance are the largest processors of rare earths to separate them by solvent extraction outside of China, and Energy Fuels is the sole producer of clean mixed rare earth carbonates in the Americas.

I am watching the following juniors: USA Rare Earths, Rare Element Resources Ltd. (OTCQB: REEMF), Vital Metals Limited (ASX: VML), and Appia Energy Corp. (CSE: API | OTCQB: APAAF).

The next five years will be the critical time for the development of a domestic American or European total rare earth enabled products supply chain. Canada is at a crossroads; it may build a domestic supply chain anchored on mines and going downstream with licensed European separation, metal and alloy making, and magnet making, or it may build a trans-Atlantic one with the EU.

The game's afoot.