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STORMCROW

The Year of the Ox Is Upon Us

February 15, 2020

And They Might Not be "Rare", But They are Back!

In this issue we discuss:

- **Lithium Prices Keep Moving** With record monthly new energy vehicle sales in December in China and across the world, battery material demand continues to rise. Coming out of the boom-bust cycle in lithium, this means we are likely at the beginning of another mini-boom. Hopefully there will be a little more intelligence in handling this one versus the last one, but at least for a time we are back to the good old days, if by good old days we can refer to a couple or three years ago.

- **Speaking of Back…** Rare earths are near and dear to my heart. The recently departed US President wanted to make rare earth supply a scapegoat for all that was wrong with trade, and this enthusiasm is now being reflected in prices. Problem is, it probably shouldn't be, not yet, and it's being reflected in ways that suggest speculation and not fundamental demand. We will discuss.

- **Bellying Up to the Trough** And with a mini-frenzy around critical materials and the capital markets in general, we are seeing profoundly undeserving companies and profoundly greedy bankers taking advantage. We are going to call some people names. Stay tuned.

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As a Matter of Introduction…

We've been writing this monthly newsletter for a while now, much more than a year. To be honest, this was a way for a firm that isn't able to publish a lot of the research we do, because it is proprietary and done under NDA, to maintain contact with some readers. The volume of contact and comment is increasing, so that part appears to be working. We hope you enjoy these and find them of value.

And for those who don't know, Stormcrow deals with the markets for critical materials. Generally speaking, what amounts to a critical material is in the eye of the beholder, but we think of them as materials that are essential to making a product with the characteristics intended by its designers, even if those materials are not anything like the highest-cost item on a bill of materials. As an example, think lithium in the battery of your cell phone. That lithium costs pennies as a raw material, but if your cell phone manufacturer was forced to do without it then the resulting cell phone would have a very, very different operating experience than it currently does.

Over the coming months, we are going to deal with our views of the market prospects for some critical materials, and interesting facts about others. We will talk a little about technology and the impact, both good and bad, that it can have on demand for critical materials. We hope you find this interesting and worthwhile! Note that when not writing newsletters like this one, Stormcrow Capital functions as a corporate adviser (capital markets / financing / M&A) in the critical materials sector. We are registered as an Exempt Market Dealer in Canada *(additional disclosures included at the end of this note).*

Happy Lunar New Year!

We've just gone though January and Lunar New Year is with us. The period coming into Lunar New Year is always one for restocking, and with that a high point in pricing. For lithium, the restocking has been especially good for prices this year. In 2019, lithium chemical prices were still dropping and some spodumene miners were forced to curtail production, so lithium chemical supplies became even more dependent on a limited stockpile of feedstock in China and the brine producers of South America. Obviously, demand in 2020 was muted due to the pandemic, but prices have been moving strongly higher and we are now seeing something that looks more like a sustainable market.

So, from the end of December to the end of January:

Battery-grade $LiOH \bullet H_2O$ UP 16.2%

Battery-grade Li_2CO_3 UP 41.9%

Battery-grade $CoSO_4 \bullet 7\ H_2O$ UP 23.7%

Battery-grade $NiSO_4 \bullet 6\ H_2O$ UP 6.0%

In addition, spodumene prices are going higher, which suggests that restocking of feedstocks in China is occurring. All this is positive for the suppliers, especially since nothing has occurred that would suggest any prices have risen to the point of substitution or thrifting being considered, and there are no present supply shortfalls. Right now, all is good and it would appear to have the potential to become better over coming months, providing additional supplies of spodumene judiciously re-enter the market.

They Were Never Rare, but We Love 'Em Anyway

We started looking at the market for rare earths in late 2009 and ran head-first into the drastic reduction in export quotas made by Chinese authorities and then the unofficial albeit brief embargo on rare earth shipments. Our conclusions then remain our conclusions now. Rare earths are not "rare", there are commercial deposits in a lot of places and the level of demand is still low by comparison, but there are a lot of things that need to be done to rare earths before they can be used. Mining is maybe the least of that. So bringing new supply into the market is not simple. Ask the former management of Molycorp or the present management of Lynas.

On the demand side, we saw what happens to rare earth demand if prices skyrocket back in 2011. The rare earths are perfectly fantastic engineering materials to have, if you can

get them reliably and at a fair price. While there are many uses where there is, technically, no direct material substitute, there is no shortage of technological substitutions. For example, if I am hell-bent on using a NdFeB magnet in a motor for a new energy vehicle application, if Nd prices soar then there is pretty much nothing I can do to get a comparable NdFeB magnet other than pay up. But I can also redesign the application to use a bigger, heavier and less efficient induction motor, and keep right on trucking. Implementing those technological substitutions takes some time, so there is some delay in demand destruction but it happens all the same.

And those fools that keep squawking about "paradigm shifts" and how the move to electric vehicles means prices for critical materials will constantly move up and to the right also need to remember two important things. The first is that the automotive industry is a low-margin, cutthroat business. If rare earth prices rise too high, the automakers can't afford to use them. As we've said before, building a Honda Civic is not building a fighter-bomber for the US Air Force. Money is THE object, not no object. The second is that volatile pricing reflects volatile supply. If you design a new energy vehicle, let's say the darling of the day in China, the Wuling Hongguang Mini which is outselling everything else by a long way, then you need RELIABLE supply of your raw materials and components. Anything that suggests materials might go into short supply or become unavailable is death. So you either proof your supply chain against that possibility, or you don't use that material. Period. Otherwise, you might go out of business.

Exhibit 1 – The Top-Seller in China, the Wuling Hongguang Mini EV!

Source: Wuling

But here is what the rare earth prices have done over the last while, and some thoughts about what is driving this behavior:

Exhibit 2 – Important Rare Earth Prices Then and Now (as oxides, USD/tonne)

Period	La	Ce	Pr	Nd	Tb	Dy
Avg 2012 to 2019	$ 6,202	$ 5,934	$ 70,135	$ 60,021	$ 750,530	$ 396,099
Avg 2020	$ 1,646	$ 1,666	$ 45,506	$ 48,480	$ 662,794	$ 259,870
Current	$ 1,495	$ 1,505	$ 63,200	$ 91,150	$ 1,362,500	$ 353,300

Source: Asian Metal

First, some observations. The average prices in 2012 were still coming off ridiculous historical highs from 2010 and 2011, driven by government-mandated supply disruptions. For anyone that is inclined to say "Well, that just tells us that prices have room to grow!" my response is stop being an idiot. Prices collapsed to historic LOWS in the period following that rocket-ride up, and that was because demand was crushed for a period of time. We only got back into a normal mode of pricing and behavior around 2016. It took that long for the market to get back to something resembling normal. I hate to say this, but there are still suppliers in China longing for the "good old days" of 2010 and 2011, and they, too, forget that those "good" days unavoidably lead to years of really bad ones.

Second, take a close look at some ratios. Let's look at the price of praseodymium (Pr) oxide versus neodymium (Nd) oxide. Both are used in magnets, although we usually talk about the most common rare earth magnets as being "neodymium magnets" and we refer to them sometimes as NdFeB, since their major metal constituents are iron, neodymium and boron (in that order). But Pr is a better metal for the job, in some ways, than Nd, it's just naturally rarer. And because Pr also has uses in the ceramics industry, where they need just a little but it does important things in coloring glazes and the like, Pr has also usually been more expensive than Nd. In the individual years from 2012 to 2020, the average ratio of praseodymium oxide price to neodymium oxide price was 1.26 ± 0.25. Only occasionally and for short periods of time was the price of neodymium oxide higher than that of praseodymium oxide. Right now, that same ratio is 0.69. That's a 2.3 standard deviation difference from normal, and that's odd.

Or look at the ratio of terbium (Tb) oxide to dysprosium (Dy) oxide. Both have a number of minor uses, but their biggest claims to fame are that they are added to those NdFeB magnets in small quantities because the greatest failing of NdFeB magnets is that they don't like to be heated up. As they heat up, they lose their magnetic strength and, above a critical temperature, they stop being magnets and become a block of metal until they are re-magnetized. If this happened in your electric vehicle, this would be very bad, you would have bricked your car. Adding Tb and Dy to the magnet effectively raises the temperature at which this might happen, adding an important safety factor. And Tb is much better at this function than Dy but, again, it is rarer. So we might expect that Tb is going to be priced higher than Dy and it usually is. Between 2012 and 2020, the

average price ratio of terbium oxide to dysprosium oxide was 2.14 ± 0.40. The current ratio of pricing is 3.86, which is a whopping 4.3 standard deviations from normal, and that's really odd.

I know some of the people in China who speculate on physical materials. They use some of their wealth to buy significant quantities of things like battery-grade lithium hydroxide at times when these materials are being hyped in order to try to profit from price swings. Given the small size of markets like that for terbium oxide, for example, it doesn't take much capital to move the needle on demand and change prices. In these cases, though, if we had to guess we would attribute the movements to two different sources of buying.

When it comes to the unreasoning demand for Nd over Pr that has pushed up the price for neodymium oxide, we would guess that the buying is amateur speculating. These buyers know that neodymium magnets are a Good Thing, so they are buying up physical neodymium oxide and putting it away. They are not necessarily aware that praseodymium oxide is also a Good Thing, maybe even a Better Thing. So the price of neodymium oxide is being increased without much regard to reality. As an example, once the price of neodymium oxide gets much over $80,000 per tonne, users generally begin to thrift and consider other options. Over $100,000 a tonne, all bets are off.

But in the case of terbium oxide, the story might be different. It would appear entities are buying Tb without it being generally known as the better material for some applications compared to Dy; people discussing magnets generally talk about Dy being added to magnets to improve their performance, not Tb. And there are some other high-value, exclusive uses of terbium like the alloy Terfenol-D that is used in high-powered sonar systems (think military use) and as a constituent of solid-oxide fuel cells. Here, it seems likelier to me that knowledgeable end-users are stockpiling terbium oxide, just in case. Stockpiling is an obvious way to overcome volatility of supply. Who exactly is doing this buying, well, that isn't clear.

But it's apparent that the interest in rare earths is back, and we will start to keep a closer eye on the space.

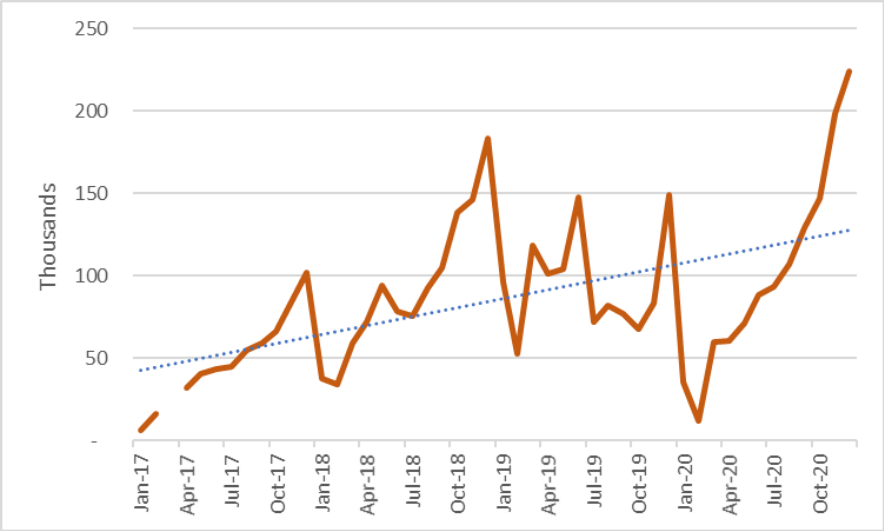
It Worked.

After the arrival of the SARS-CoV-2 virus and with the shutdowns in China that followed, vehicle sales in general hit the skids. And coming off a (relatively) small base, new energy vehicle sales did not fare well at all. But with a lot of effort and a lot of vigilance, China's economy rebounded. Many governments at all levels in China worked together to keep subsidies for vehicles, especially new energy vehicles, healthy. That effort paid off.

New energy vehicle sales in 2020 were a record. 1.244 million new energy vehicles, with a rough average battery size of 43 kWh per vehicle, were sold in 2020. Compare that to the 1.144 million sold in 2019 with average battery size of 41 kWh per vehicle. We can

argue that sales would have been a lot higher or a little higher or whatever if COVID-19 hadn't punched a hole in the middle of the year, but what we can't argue is that such sales are increasing. This is partly because of continuing subsidies and partly because of increasing quality of and variety in purchase options. But monthly sales are on the way up.

Exhibit 3 – Monthly New Energy Vehicle Sales in China



Source: Various

Now, sales in January 2021 have declined month on month, but that isn't shocking even in a regular year. What is clear from the trendline is that monthly sales are generally increasing, with a lot of noise, and as long as subsidies (both social and financial) are maintained then China can switch a larger and larger number of new vehicle sales to the new energy vehicle category. Whether they should be putting that effort in right now is more of an open question, but we can't argue that higher sales of new energy vehicles won't be good for critical materials prices.

For Shame

Obviously, I work in the financial services industry. Which means a lot of what I do is related to the capital markets. As a sell-side analyst, I spent a big part of my time creating justifications for why the stock of a company would be worth more in the future than

people were willing to pay for it today. That job is easy when the answer is that the company produces a critical material that will be worth a lot more in a year than it is worth today, even though people who don't understand the pricing of that material at least as well as I do might not realize that yet. And sometimes there is a lot of muttering about 'multiples' and other factors that make us feel better but that, at the end of the day, are basically connected to how many buyers are excited about companies like the one in question.

Trying to separate the winners from the losers is hard. At the earliest stages in the development of a junior mining company, maybe the correct description is impossible. Achieving success in any business is a serial process. That is, the company has to find a strong deposit in a solid mining jurisdiction, have a management team that is capable of developing that deposit correctly, be lucky enough to find themselves in an environment where enough investors care to give them the capital to get the job done AND be able to produce something that enough buyers need so that they can get the off-take agreements necessary to convince investors and banks that they are going to make a go of it. If anything goes wrong, and that can be related to market timing or changes in technology that crush demand for their product or even unforeseen problems with management, the likelihood is that the company will simply become another failed junior.

Far easier than picking winners is picking losers. There are a horde of publicly-listed (or wannabe) companies that are in business either to sell some more stock to keep paying management an exorbitant salary or allow the early investors in a crummy company to sell out their stock to someone at a higher price than they paid and leave those new shareholders holding the bag. I've been fortunate enough in my career to come across a few of these when they were valued at some stratospheric level, and I've learned not to dismiss my identification of fundamental flaws in these companies with a shrug and the thought that "someone else must have done the work, so this thing must be for real". If there is a fundamental flaw in the company, it is very likely worthless, no matter what the stock price tells you.

I do believe that my background helps. I was trained as a physicist. I hope that means I think logically and carefully. I'm as prone as anyone else to jump to conclusions, but I also hope I am willing to adjust those conclusions if new evidence dictates that I do so. I'm also inclined to go to the source of information rather than just taking a company's word for it. I don't view myself as any smarter or any better than any other analyst out there, though. Anyone can do the work. That means that there are plenty of other people who should be able to look at a rotten fish of a company and say "Man, that thing stinks."

Which brings me to the point of this rant, a company called USA Rare Earth. News about the company always says something like "USA Rare Earth LLC is developing the Round Top

rare earth deposit in Texas". It sounds very impressive. A recent article by Reuters asserts that the company has hired Goldman Sachs and Bank of Montreal to assist them with a public listing, either via IPO or SPAC, that might value the company at over USD$1 billion. Also impressive. But what is absolutely most impressive to me is that no one in those very impressive banking groups is standing up to point out that this company is probably worthless. That's not impressive, that's just shameful.

Before US Rare Earth LLC wrapped themselves in the Star-Spangled Banner they were wrapping themselves in the Texas state flag as Texas Rare Earths. The company has been around for a long while. Indeed, I remember Round Top from back in 2010. In 11 years, the project has advanced remarkably little. When it was first introduced to me, I asked an executive from the company what their *in situ* grade was. He smiled and answered in a bit of a Texas drawl that "our grade isn't high, but we've got a lot of it!" I replied that where I come from, we call that dirt. My analysis stands.

Round Top is one of many projects that are uneconomic unless they produce and sell a stream of products that resembles the entire periodic table. From the company's PEA issued in 2019:

Exhibit 4 – Interesting Elements in Round Top Deposit (aka the Periodic Table)

	Units	Measured	Indicated	M+I	Inferred
TONNAGE	*Metric Tons*	200,000	164,000	364,000	735,000
Dy	*ppm*	30.31	30.41	30.33	29.61
Lu	*ppm*	8.83	8.64	8.79	8.49
Li	*ppm*	462.44	441.12	458.33	445.20
Hf	*ppm*	79.53	78.66	79.36	77.33
Zr	*ppm*	1,106.60	1,093.56	1,104.09	1,049.38
Al	%	6.58	6.46	6.56	6.52
K	%	3.30	3.28	3.30	3.21
Pr	*ppm*	10.29	10.18	10.27	9.97
Nd	*ppm*	27.91	27.77	27.88	27.55
Sm	*ppm*	10.07	10.04	10.06	9.85
Tb	*ppm*	3.46	3.47	3.46	3.30
Y	*ppm*	214.46	211.92	213.97	195.84
Sc	*ppm*	0.67	0.70	0.68	0.71
U	*ppm*	33.67	23.83	31.77	8.38
Be	*ppm*	32.99	28.64	32.15	18.22
Ga	*ppm*	70.32	46.86	65.80	16.96
Sn	*ppm*	137.73	136.60	137.51	134.94
Nb	*ppm*	175.26	119.87	164.58	46.52
Fe	%	1.06	0.97	1.04	0.82
Mg	%	0.03	0.02	0.03	0.01
Mn	*ppm*	503.96	334.47	471.28	118.86
Na	%	4.02	2.73	3.77	0.95

Source: TMRC NI 43-101 PEA Study, 2019

The company dresses Round Top up as a rare earth deposit. Not that we would suggest that the California Rare Earth Mine being harvested by MP Materials is the be-all or end-all of rare earth mines, but a comparison is worthwhile. At Round Top, *in situ* grade of neodymium is listed, above, at about 28 ppm. That is, for every tonne of ore extracted it contains just 28 grams of neodymium that might or might not be able to be recovered and purified for eventual sale. The same number for neodymium at MP Materials' Mountain Pass Mine is about 9,600 grams per tonne of ore, or 343 times as much.

The lowest grade rare earth mines in the world are the ionic clay projects in south China and, prospectively, in Brazil, Chile, Madagascar, parts of Africa and perhaps Australia. They typically have *in situ* grades for total rare earth oxides in the 1,000 ppm range but are economically viable because simple solutions of ammonium nitrate can be used to extract the rare earths using *in situ* leaching. At Round Top, overall grade of total rare earth oxides is less than 400 ppm. The ionic clays in China are harvested economically because a simple fertilizer solution can be trickled through the soil to *in situ* leach the rare earths and put them into solution, without dissolving many other contaminant metals in the soil that will cause problems when trying to purify rare earths for sale. At Round Top, soil must be moved by man and machine to leach pads where expensive, strong acid will be used to try and recover the rare earths but will necessarily dissolve dozens of contaminant metals that will make purification more difficult and expensive, followed by the waste then being moved to storage areas afterward. Given this is a PEA, there has been no significant metallurgical work done to prove that the rare earths (and lithium and niobium and uranium and magnesium and on and on and on) can be easily and inexpensively separated from one another. This is just an optimistic little estimate of cost ("Recovery $3.96!"):

Exhibit 5 – Operating Cost of the Round Top Deposit

Item	*Cost ($/Tonne)*
Mining*	$ 2.67
Crushing & Conveying	$ 0.91
Heap Leach	$ 3.55
Recovery	$ 3.96
Rail Systems	$ 0.23
G&A	$ 1.78
Sub Total	$ 13.11
Contingency (20%)*	$ 2.50
Total	$ 15.61

Source: TMRC NI 43-101 PEA Study, 2019

We know that if you pour enough acid on rock, you will dissolve many of the metals within it. That isn't in question. What is in question is whether you can eventually and cost-effectively extract materials that are pure enough to sell at market prices. If people wanted to buy impure mixtures of chemicals, you could just sell them the dirt. WITH NO EVIDENCE, this PEA suggests that the following (partial, we believe) list of products can be sold by the company from a Round Top Mine:

Exhibit 6 – Base-Case Price Assumptions, Round Tap PEA

	Product	Base Case Price Assumption	
Rare Earth Oxides (&Related)	Yttrium Oxide	$ 3.60	$/Kg
	Praseodymium Oxide	$ 54.50	$/Kg
	Neodymium Oxide	$ 44.00	$/Kg
	Samarium Oxide	$ 1.83	$/Kg
	Europium Oxide	$ -	$/Kg
	Gadolinium Oxide	$ -	$/Kg
	Terbium Oxide	$ 575.50	$/Kg
	Dysprosium Oxide	$ 270.50	$/Kg
	Thulium Oxide	$ -	$/Kg
	Ytterbium Oxide	$ -	$/Kg
	Lutetium Oxide	$ 618.63	$/Kg
	Scandium Oxide	$ 1,040.76	$/Kg
Tech Metals	Uranium Oxide	$ 56.10	$/Kg
	Thorium Oxide	$ -	$/Kg
	Lithium Carbonate	$ 13.75	$/Kg
	Zirconium Oxide	$ 15.12	$/Kg
	Hafnium Oxide	$ 864.00	$/Kg
	Beryllium Hydroxide	$ 220.00	$/Kg
	Gallium Oxide	$ 162.00	$/Kg
Sulfates	Aluminum Sulfate	$ 0.21	$/Kg
	Iron Sulfate	$ 0.10	$/Kg
	Magnesium Sulfate	$ 0.13	$/Kg
	Manganese Sulfate	$ 1.19	$/Kg
	Potassium Sulfate	$ 0.43	$/Kg
	Sodium Sulfate	$ 0.20	$/Kg

Source: TMRC NI 43-101 PEA Study, 2019

Most of these base-case prices are not outlandish compared to long-term price averages. Many of the markers for these materials wouldn't be overly impacted by the hypothetical annual production levels from a developed Round Top, in the unlikely event this ever happens. Some, like the markets for yttrium, scandium, lutetium amongst them, definitely would. The question is whether, at $3.96 a tonne of dirt, the company has a chance of making a pure enough product to sell to anyone.

For example, the purity of neodymium oxide required to achieve anything like the base case price of USD$44.00 per kg listed above is a minimum 99%. But this grade also assumes that most of the remaining 1% of material in the neodymium oxide is rare earth oxides of similar mass, like praseodymium oxide, and not potassium or iron.

As another example, battery-grade lithium carbonate does, occasionally, sell for prices as high as USD$13,750 per tonne. But it is a 99.5% pure chemical, with very strict limitations on content of contaminants like aluminum and iron and magnesium. Ask companies like Orocobre Limited how

simple it is to make acceptable battery-grade lithium carbonate even from high-grade brines that don't contain substantial amounts of dissolved aluminum or thorium. It isn't simple, and with no proof of any kind that something like this can be done against all evidence collected in mining over hundreds of years (You don't believe that a huge, high-volume copper mine might not have a little beryllium or uranium or even rare earth in there that could be pulled out of solution to easily make a few million dollars more per year? Why aren't all mining companies doing such things?) it is not something that should even remotely be taken for granted.

Regarding the rare earths in Round Top, alone, we have some skepticism. The PEA tells us that the minerals in the dirt from Round Top (I can't bring myself to call it "ore" or to call Round Top a "deposit" because there is no evidence this thing will be economic in any way) that contain rare earths are most likely bastnasite, the same mineral found in the California Rare Earth Mine, and an unidentified yttrofluorite (Quick, what do you make when you mix fluorites with acid? Hint: Don't drink it, pour any of it on your skin or allow it to be in constant contact with most metals used to build a hydrometallurgical plant, because it will slowly but surely eat its way through just about anything…). Rare earths all come from the same places and the ratios of their creation are pretty constant across rare earths of similar mass. Yet, at Round Top, the amount of lutetium in the samples is anomalously high compared to levels of yttrium. The ratio between dysprosium and terbium is also anomalously high. We note that the rare earths are notoriously difficult to measure properly, especially at low levels in the presence of multiple contaminants. We would view even the amounts of rare earths measured in these samples with a great degree of caution until much larger samples are processed and measured.

What all this screams at me is "caveat emptor". Every junior mining project comes with risk, we've noted that. But just because every project comes with risk does not mean we abandon all logic and run, screaming, over a cliff. There are very good reasons to be highly skeptical of the prospects for Round Top to become a working mine, and there are a host of other far better development-stage rare earth projects in the United States, never mind North America. I can understand the greed driving a company like USA Rare Earth to try to take advantage of a strong market to get their one and only project publicly listed and sell some shares at a high price. And I can understand if an investor wants to treat putting some money into something like USA Rare Earth as a trade. All that is normal for our industry. What I can't understand, apart from simple financial gain, is real investment banks with real reputations rushing to help separate investors from their money to enrich a junior mining company with essentially no commercial prospects. The involvement of firms of the scale of Goldman Sachs will help convince investors that a project like Round Top is real. That is, simply, shameful.

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