

Critical Metals

For a Sustainable World

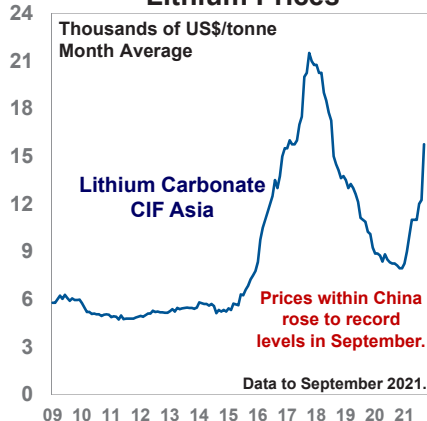
Capitalight
Research Inc.

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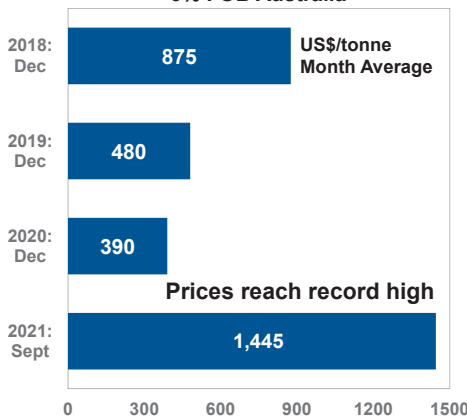
Lithium Prices



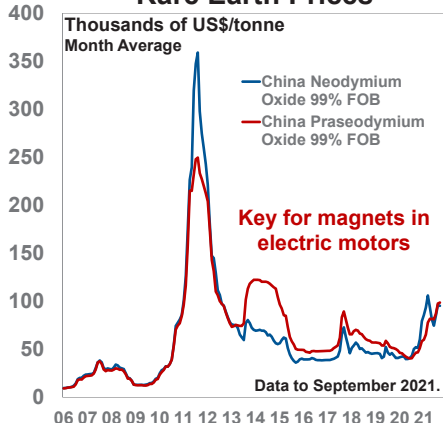
Source: BMI, Bloomberg, Capitalight Research.

Spodumene Concentrates

6% FOB Australia



Rare Earth Prices



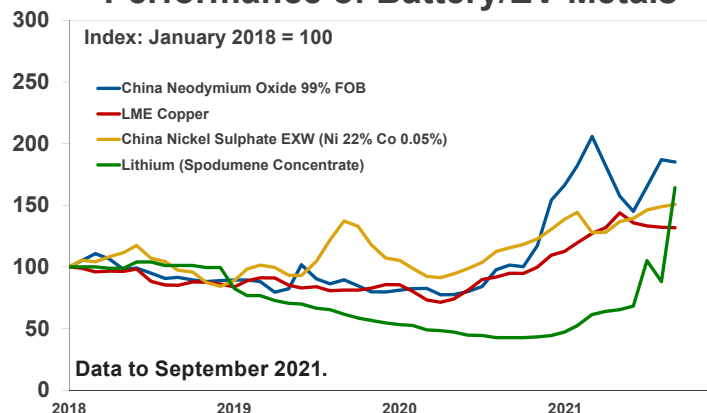
Source: Asian Metals Inc, Bloomberg, Capitalight Research.

- Rare Earths & Magnets: Extraordinary Supply-Chain Risks Point to High Prices Ahead.
- Lithium prices surge, with tight feedstock supplies.
- China Evergrande's debt crisis triggers risk-off sentiment in commodity & financial markets.

Rare Earth Prices Outperform

All of the 'critical mineral' prices covered in this report – for copper, nickel, lithium and 4 of the 17 rare earth elements (REEs) – have performed well coming out of the 2020 pandemic. However, the rare earth oxides for neodymium, dysprosium and terbium (1 light and 2 heavy REEs) have outperformed – even against the base metal bellwether copper – boosted by exceptionally strong underlying demand and restocking. A military coup in Myanmar – normally supplying 50% of heavy rare earth feedstocks to China – raised uncertainty over supplies earlier this year, lifting prices for dysprosium and terbium. The border has reportedly now been closed, possibly to contain Covid-19.

Investor Watch: Relative Price Performance of Battery/EV Metals



*Based on monthly average U.S. dollar prices; yuan prices converted to US dollars.

Sources: Capitalight Research, Asian Metal Inc., BMI, LME & Bloomberg.

Supply Chain for Rare Earths

Mining & Concentration of Ore → Hydrometallurgical Treatment into an Intermediate Mixed Rare Earth Product (in Carbonate, Chloride or Oxide form) → ‘Separation’ into Individual Rare Earth Oxides → onward flows to produce Refined Metal Ingots, Alloys, Magnets (e.g. NdFeB) and other Manufactured Products. **Source: With Guidance from Hatch.**

Two of the biggest transitions needed to achieve global decarbonization – the shift to the electric vehicle and renewable energy & storage (wind & solar power) require REEs, given their exceptional magnetic and conductive properties. In particular, the single-largest use of REEs is in the manufacture of permanent magnets for the motors/drive trains of electric vehicles and wind turbine generators (with current technology). REEs also have important applications in smart phones, computer hard drives, flat screen televisions, catalysts and medical imaging & lighting. Significant defence uses include electronic displays, missile guidance systems, lasers, radar and sonar.

Neodymium is seen as the most crucial among the light REEs – as it is the main element used in the creation of permanent EV magnets. *Praseodymium* is often combined with neodymium to create even better magnets and blended with magnesium to produce an alloy for aircraft engines. A small amount of even scarcer heavy rare earths – *dysprosium* and *terbium* – is added to allow higher temperatures.

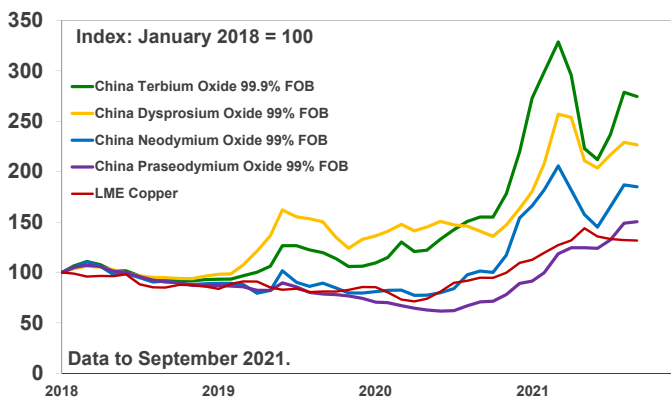
China’s Absolute Dominance in Rare Earths & Magnets Poses Supply Risks For Western World Manufacturers

China has had a ‘strategic vision’ for developing its rare earth and downstream manufacturing industries for three decades – something Western countries have lacked. China now dominates the global supply chain – not only in mining (60%) and the production of ‘separated’ rare earth oxides, refined metal & alloys (about 85%), but also in secondary manufactured products such as Neodymium-Iron-Boron (NdFeB) magnets – the most common type of magnet used in EVs.

China’s focus on developing ‘process technology’, its willingness to site processing facilities using large amounts of chemicals and, in the beginning, less stringent environmental regulations have been key in the country’s expansion. While global REE deposits are not ‘rare’, it is unusual to discover deposits that are large enough and concentrated enough for commercial ore extraction. Rare earths are normally found mixed together and require difficult chemical treatment to separate the individual elements. In addition, REE material often contains radioactive thorium and uranium, requiring careful handling and treatment.

Today, China’s Ministry of Industry and Information Technology (MIIT) and Ministry of Natural Resources set annual quotas (announced semi-annually) for both rare earth ‘mine production’ and ‘treatment & separation’ – allocated to producing provinces, who in turn allocate quotas to each of the six major state-owned enterprises (SOEs) involved in rare earths. The mining production quota for 2021

Heavy Rare Earth Prices Outperform



Sources: Capitalight Research, Asian Metal Inc., BMI, LME & Bloomberg.

Rare Earth Mine Production (tonnes of rare earth oxide equivalent)

	2019	2020
China	132,000*	140,000*
United States	28,000	38,000
Myanmar (Burma)	25,000	30,000
Australia	20,000	17,000
Madagascar	4,000	8,000
India	2,900	3,000
Russia	2,700	2,700
Thailand	1,900	2,000
Vietnam	1,300	1,000
Brazil	710	1,000
Burundi	200	500
Canada**	-	-
Other Countries	66	100
Total World	220,000	240,000

Source: U.S. Geological Survey and Capitalight Research.

*China's mine production quota is set semi-annually by the Ministry of Industry and Information Technology (MIIT) and the Ministry of Natural Resources and awarded to provinces, who in turn award REE mining production quotas to six state-owned mining companies. 2021:H1 quota was increased by +27% y/y to 84,000 tonnes and recently increased for the year as a whole by 20% to 168,000 tonnes (a new record). Actual production may exceed quota due to unregulated mining.

**Canada's first rare earth mine – Nechalacho in the Northwest Territories, owned by Cheetah Resources & Vital Metals Ltd. of Australia – started production in May 2021. Concentrates are being produced via sensor-based sorting and are being transported to an owned hydrometallurgical plant under construction in Saskatoon, for production of "mixed rare earth carbonates"; first feedstock expected in December 2021. The carbonates will then be shipped to REEtec of Norway for separation into individual high-purity rare earth oxides and eventual sale into the supply chain. This mine involves the T-Zone & Tardiff-Zone deposit.

was recently raised by 20% to 168,000 tonnes – intended to ease currently tight supplies for Chinese magnet manufacturers. The 'treatment & separation' quota was also lifted by 20% to 162,000 tonnes. Imports of REE feedstocks totalled about 47,000 tonnes in 2020, mostly from Myanmar, Malaysia and Vietnam.

The six SOEs with mining quota are: China Northern Rare Earth Group (with the world's biggest mining operations), China Southern Rare Earth Group, Chinalco Rare Earth & Metals Co., Guangdong Rising Rare Metals, China Minmetals Rare Earth Co. and Xiamen Tungsten. (It is reported that China may consolidate these SOEs into two large entities to tighten control.)

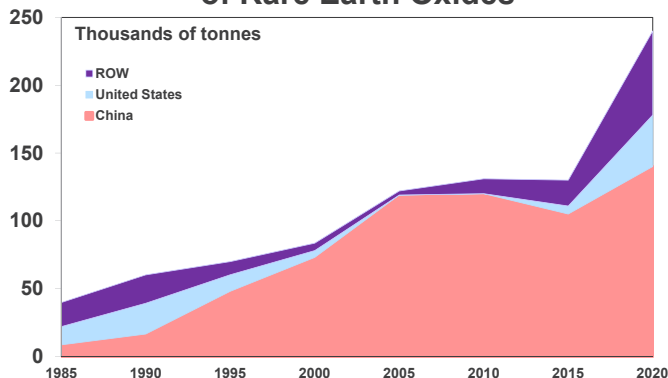
Rare earth mine development increased in countries outside China after the 2010-11 price spike – triggered by China's temporary export embargo on Japan during a dispute and reduced export quotas. For example, JOGMET of Japan contributed funding for the operations of Lynas Corporation in Western Australia as a way to diversify its REE supplies from China.

However, a severe lack of 'separation capacity' currently exists in Western countries – just at

the inflection point when rare earth demand for decarbonization & electrification is likely to accelerate. In the United States and Canada, no 'separation' capacity currently exists. As a result, U.S. mixed rare earth carbonates from the MP Materials' mine & processing plant in California must be exported to China/Asia for 'separation'. Neo Performance Materials (a Toronto-based corporation) owns the only commercial REE separation plant presently operating in Europe at Sillamäe, Estonia.

China also dominates the world's supply of permanent rare earth magnets – supplying 73% of U.S. imports in 2021 to date and 98% of EU demand. China has about 23 domestic permanent magnet plants and uses the Export VAT Refund Scheme to incentivize domestic production and subsequent export of permanent magnets over rare earth materials (which don't receive any tax refund, as opposed to 13% for magnets). China's manufacturers also benefit from a 13% rebate on VAT applied to raw materials and typically receive a 10% raw material subsidy from local governments. Five major foreign companies operate in China,

Global Mine Production of Rare Earth Oxides



Major Events:

1990: China declares rare earths a 'protected and strategic mineral' and proceeded to control production and processing, introduced export quotas (ended in 2015) and sought to dominate the supply chain for important applications such as NdFeB permanent magnets.

1998: The Mountain Pass mine (sole U.S. producer) ceases large-scale operation.

2007: The Mountain Pass mine shuts down completely due to environmental concerns and Chinese competition.

2010: China temporarily halts exports to Japan and reduces export quotas, pushing REE prices to record highs and spurring mine investment in other countries.

2020: China's share of global mine production drops to 60% from 92% in 2010.

Source: China's MIIT, U.S. Geological Survey, Investment Monitor

including Magnequench (owned by Neo Performance Materials of Toronto), Hitachi Metals of Japan and Vacuumschmelze (VAC) of Germany. In contrast, the United States has no current capacity to produce NdFeB magnets, though Samarian-cobalt magnets (SmCo) are produced.

Unless remedied, this overwhelming reliance by the United States and Europe on permanent magnet imports from one country – China – points to stepped-up economic & strategic vulnerabilities in manufacturing, given the huge increase in demand likely in the auto and power sectors over the coming decade.

U.S. imports of permanent magnets have been fairly modest in recent years at US\$380.5 million in 2019 (pre-pandemic) and an annualized

US\$464.4 million in 2021 to date, but will soar over the coming decade as OEMs build out electric vehicles. Recognizing this vulnerability, General Motors and General Electric announced in recent days that they will team up to evaluate how to improve access to rare earth and magnet supplies, as well as copper and steel.

The Canadian Connection

Interestingly, Neo Performance Materials – a Toronto-based company – is the only company in the world with parallel dual supply chains for rare earths – both inside and outside China – involving separation and advanced materials.

While not a mining company, Neo owns three separation plants in Sillamäe, Estonia (within the European Union), Zibo, China (south of Tianjin) and Jiangyia, China. Neo produces REE alloys & magnetic powders in Thailand and China (Tianjin), REE magnets in China (Tianjin & Chuzhou), REE environmental catalysts (in Estonia & China), LED/Electronic specialties (in South Korea and Oklahoma) and undertakes Rare Metals Refining & Recycling in Estonia, Germany and Peterborough, Ontario.

Neo and Energy Fuels recently launched an initiative to supply U.S. and European markets with value-added rare earth products processed from low-cost U.S.-based feedstock. Monazite sands produced by The Chemours Co. in Georgia will be processed into a mixed REE carbonate by Energy Fuels in Utah, then processed by Neo at its separation plant in Estonia into neodymium and other value-added REE products – for sale to European customers and to Neo's REE magnetic powders plant in Thailand, supplying markets in Thailand, Japan, Europe and North America.

Supply Chain Vulnerabilities Starting To Spur Investment

The lack of rare earth 'separation' capability outside of China is starting to trigger development, with the following projects underway (among others):

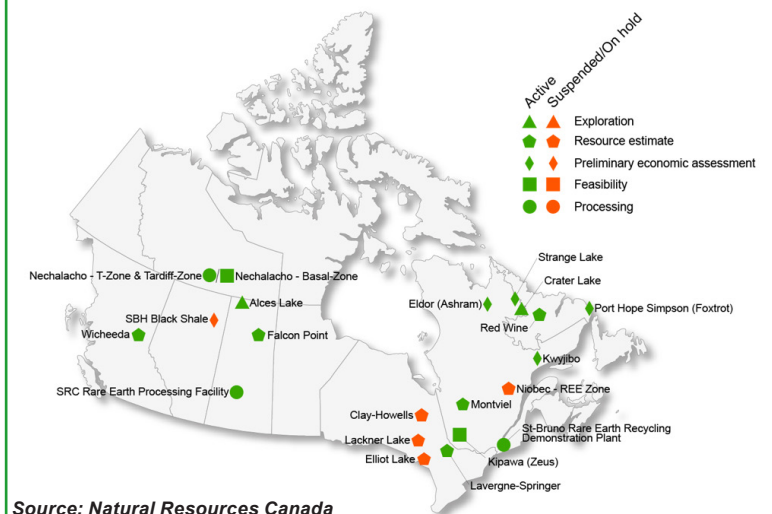
In Canada, the Saskatchewan Research Council (SRC) plans to establish a commercial 'Rare Earth Processing Facility' in Saskatoon to serve as a hub for the development of a fully-integrated rare earth industry. The facility will be constructed in two stages – the first, will include a Monazite Processing Unit (MPU) and a Solvent Extraction Unit – currently underway with completion expected in 2023. This unit will produce 'intermediate mixed rare earth product' – to be 'separated' in a second-stage plant (the first of its kind in Canada) into individual rare earth oxides (e.g. neodymium oxide, praseodymium oxide and others, as the market requires). The second stage is expected to be operational by 2024.

The SRC facility will focus on the treatment of monazite ore, given its abundance across the globe and in northern Saskatchewan. The rare earth composition of monazite is particularly attractive, given its high content of neodymium and praseodymium, required for magnets. Saskatchewan is a major uranium producer and one of the by-products is raffinate containing REEs. Monazite is also present in the tailings of titanium ores, increasing its availability. We note that Saskatchewan is ranked as one of the most competitive mining jurisdictions in the world.

In the United States, the Defense Department has recently awarded funding (under DPA Title III technology investment agreements) for several projects including 1) the separation of rare earth elements at the Mountain Pass mine in California (instead of sending the mixed rare earth concentrate to China/Asia for further processing), and 2) the development of a 5,000 tonne per year light REE separation facility by Lynas Rare Earth Ltd. at Hondo, Texas, with feedstock from its operations in Western Australia – possibly co-located with a proposed heavy REE facility.

In Europe, REEtec of Norway appears close

Canadian Rare Earth Projects



Source: Natural Resources Canada

The Nechalacho-Basal-Zone deposit of Avalon Advanced Materials is still to be developed.

to starting a 'separation' plant in Norway, with environmentally friendly technology (low energy consumption and 100% hydro-electric power). A 'separation' facility is also planned for Pulawy, Poland by Mkango Resources and Grupa Azoty Zakłady Pulawy S.A. – adjacent to Grupa's fertiliser & chemicals complex, with feedstock from a mine in Malawi. A feasibility study is due for completion in 2021:Q4.

In the United Kingdom, rare earth developer, Pensana, is in the process of developing a large separation plant in the Saltend Chemicals Park in Northeast England. The material will be sourced from the Longonjo project in Angola.

U.S. Launches Trade Investigation Into Imports of Rare Earth Magnets

On September 24th, the U.S. Commerce Department launched a Section 232 investigation to determine the effect on U.S. 'national security' – specifically from imports of Neodymium-Iron-Boron permanent magnets. The probe follows a White House recommendation that vulnerabilities be assessed within the supply chains of four vital sectors – 'critical minerals and materials', semiconductors, large capacity batteries and

pharmaceuticals, as called for by Executive Order of President Biden. This recognizes both the economic and military significance of these magnets and China's strategy promoting the rare earth industries.

We believe it would be counter-productive for the United States to implement tariffs on Chinese magnets, following the investigation. Economic policy promoting the development of secure & resilient supply chains would be more helpful – including joint action on 'critical minerals' with trade partners such as Canada. A bipartisan bill has been introduced into Congress which would give a US\$20 per kilogram tax credit for domestic production of NdFeB magnets, rising to US\$30 if all rare earth component materials are produced in the United States.

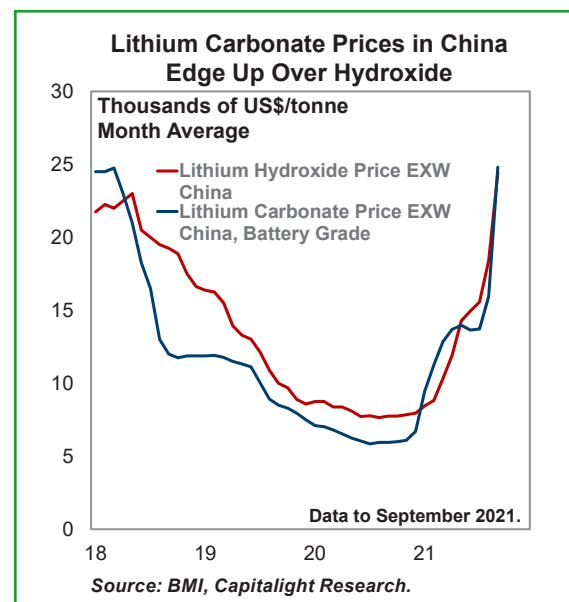
Interestingly, the European Union is hoping to repeat its recent success in building a battery sector with magnets. In the past three years, the EU has helped to attract a staggering US\$47 bn of investment in 38 battery gigafactories for EV production (through funding and co-ordination). A support package (e.g. tax incentives) is being considered to help European magnet makers compete with low-cost Chinese suppliers or to attract international manufacturers to expand in Europe. Patents can be a constraint.

Lithium Prices Soar

Lithium feedstock prices reached a new record high in September – surpassing the heights of 2017-18 during the last upswing. The average price of Spodumene Concentrates 6% FOB Australia climbed to US\$1,445 per tonne – up from US\$775 in August and a high of US\$915 back in June/July 2018. The second electronic auction of spot material by Pilbara Minerals settled at an extraordinary US\$2,440 per tonne, illustrating the degree of concern by buyers over tight supplies. Even subtracting the high auction bid, spodumene prices in September would still have averaged US\$925.

Bullish price sentiment and the underlying strength of demand lifted overall global indices of lithium prices by more than 25% in September. Upstream investment in mines by battery makers and specialty chemical producers gathered strength. Unusually, lithium carbonate prices in China edged up again over hydroxide, with relative strength in LFP cathode production rates outstripping NCM/NCA demand within China. Please see the chart below.

Chinese new energy vehicle (NEV) production and sales reached over the 300,000 unit mark for the first time in August (309,000 units produced and 321,000 units sold +194.5% y/y, monthly data). The share of electric vehicles within overall passenger vehicle sales has climbed to 13.2% so far this year. The global shortage of semiconductors does not seem to have impacted electric vehicle sales in Europe either. German auto manufacturer BMW reports that it has increased orders for batteries to keep up with growing EV demand. BMW now holds more than EUR 20 bn (US\$23.8 bn) in battery supply contracts.



Copper Prices Remain Above US\$4



Dip Buying By Investors Keeps Copper Above US\$4

LME copper prices were little changed in September at US\$4.23 per pound and have been range-bound at lucrative levels for the past three months. However, prices dipped noticeably to US\$4.10 on September 30, as the market reacted to a decline in China's Official Purchasing Manager Index for Manufacturing below the 50 mark for the first time since February 2020. Power rationing, raw material shortages and Covid-19 outbreaks accounted for the slowdown.

A series of economic and financial market developments have also contributed to risk-off sentiment and a backing up of international interest rates over the past month. Key among these has been China Evergrande's debt crisis, which will hurt prospects for China's important property market and contribute to slower GDP growth. The China Evergrande Group is the country's second-largest property developer by sales and real estate & construction account for more than 15% of China's GDP. Nevertheless, there is optimism in financial markets that the fall-out will be contained. Beijing has announced three policy measures to reign-in over-leveraged property developers.

The FOMC minutes of September 22 and statement from the Fed Chair also revealed that the Federal Reserve Board may soon begin to taper its 'quantitative easing' – provided its employment objectives are met. (Actual September employment gains at 194,000 non-farm jobs were less than expected.) This contributed to a back-up in 10-year Treasury yields from a mere 1.24% on August 2 to 1.60% by October 8. Nevertheless, investor interest in copper appears to be firm, with prices staying above the US\$4 mark.

Nickel Prices Also Well Maintained

LME nickel prices rose from US\$8.69 per pound in August to US\$8.80 in September. While also recently impacted by risk-off sentiment as well as concern over the outlook for stainless steel demand in China, nickel at US\$8.27 on October 7 remains higher than many analysts had expected.

A review of the COP 26 UN Climate Change Conference in Glasgow – as well as a re-assessment of the copper and nickel price forecasts – are planned for the next edition of the Critical Metals report.

Nickel Prices

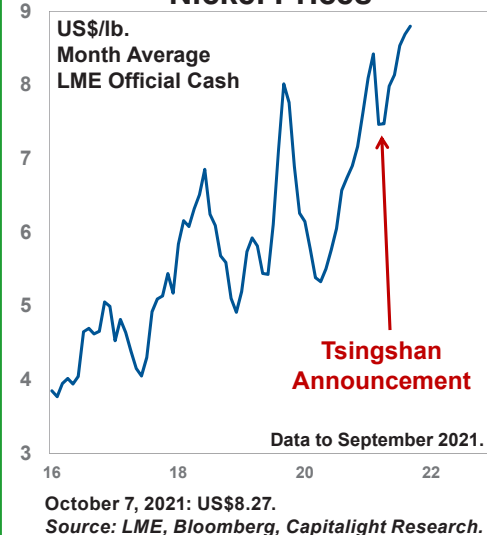


Table 1

Critical Metals - Price Trends

	2018 Annual	2019 Annual	2020 Annual	2020 Q4	Q1	Q2	2021 Q3	Sept	Latest Oct 7
Copper									
LME Copper Official Cash Settlement ¹ (US\$/lb)	2.96	2.72	2.80	3.25	3.85	4.40	4.25	4.23	4.16
Nickel									
LME Nickel Official Cash Settlement ² (US\$/lb)	5.95	6.31	6.25	7.23	7.99	7.87	8.68	8.80	8.27
SHFE Nickel, Generic First Contract ² (CNY/tonne)	102,916	110,746	109,054	120,402	131,120	128,570	143,708	146,819	143,080 (Oct 8)
China Nickel Sulphate EXW > 22% Ni, 0.05% Co ² (CNY/tonne)	28,411	30,487	29,874	30,338	35,766	35,714	39,276	40,250	(Golden Week holiday)
Lithium									
Lithium Carbonate, CIF Asia ≥ 99.2% Li ₂ CO ₃ ³ (US\$/tonne)	17,063	11,675	8,421	8,008	9,083	11,000	13,333	15,750	15,750 (Data to Sept 30)
Lithium Carbonate, CIF North America ≥ 99.0% Li ₂ CO ₃ ³ (US\$/tonne)	14,833	11,215	7,746	7,183	8,083	9,750	12,375	14,125	14,125 (to Sept 30)
Lithium Hydroxide, FOB North America ≥ 55.0% LiOH ³ (US\$/tonne)	16,771	13,521	10,629	10,183	10,458	11,750	14,333	15,500	15,500 (to Sept 30)
Spodumene Concentrate, FOB Australia 6% Li ₂ O, Lithium Feedstock ³ (US\$/tonne)	886	595	406	382	472	579	1,048	1,445	1,445 (to Sept 30)
Rare Earth Elements									
China Neodymium Oxide 99%, FOB ⁴ (US\$/tonne)	49,918	44,655	48,757	63,810	95,147	83,222	92,267	95,379	(Golden Week holiday)
China Neodymium Metal 99% FOB ⁴ (US\$/kilogram)	64	57	62	80	116	102	115	119	
China Praseodymium Oxide 99%, FOB ⁴ (US\$/tonne)	63,627	54,024	45,725	52,274	67,818	81,665	94,484	98,767	
China Praseodymium Metal 99% FOB ⁴ (US\$/kilogram)	114	103	91	92	96	104	110	112	
China Dysprosium Oxide 99%, FOB ⁴ (US\$/kilogram)	177	234	259	266	384	398	400	405	
China Dysprosium Metal 99% FOB ⁴ (US\$/kilogram)	262	307	341	348	497	516	516	513	
China Terbium Oxide 99.9% FOB ⁴ (US\$/kilogram)	455	503	664	848	1,382	1,121	1,213	1,265	
China Terbium Metal 99% ⁴ FOB (US\$/kilogram)	604	655	849	1,079	1753	1,430	1534	1597	

Sources:

1) LME, Bloomberg. 2) LME, SHFE, Asian Metal Inc., Bloomberg. 3) BMI, Bloomberg. 4) Asian Metal Inc., Bloomberg.

Table 2

Copper Price Outlook - Annual Averages

pre-pandemic

2018	2019	2020	2021F	2022F
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2.96	2.72	2.80	4.22	3.96
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Copper Quarterly Averages

Actual

Forecast

20-1	20-2	20-3	20-4	21-1	21-2	21-3	21-4	22-1	22-2	22-3	22-4
2.56	2.42	2.96	3.25	3.85	4.40	4.25					

Sensitivities	High							4.55	4.20	4.30	4.00	4.05
	Base							4.35	4.00	4.10	3.85	3.90
	Low							4.10	3.80	3.90	3.70	3.75
Probability	High							0.15	0.20	0.20	0.20	0.20
	Base							0.70	0.60	0.60	0.60	0.60
	Low							0.15	0.20	0.20	0.20	0.20

Probability-Weighted Forecast								4.35	4.00	4.10	3.85	3.90
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LME official cash settlement, US\$/lb., quarterly averages.

Nickel Price Outlook - Annual Averages

pre-pandemic

2018	2019	2020	2021F	2022F
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5.95	6.31	6.25	8.46	8.88
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Nickel Quarterly Averages

Actual

Forecast

20-1	20-2	20-3	20-4	21-1	21-2	21-3	21-4	22-1	22-2	22-3	22-4
5.77	5.53	6.46	7.23	7.99	7.87	8.68					

Sensitivities	High							10.25	10.25	10.50	9.70	8.95
	Base							9.25	9.25	9.50	8.75	8.00
	Low							8.25	8.25	8.50	7.75	7.00
Probability	High							20	21	21	23	23
	Base							60	58	58	55	55
	Low							20	21	21	22	22

Probability-Weighted Forecast								9.25	9.25	9.50	8.75	8.00
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LME official cash settlement, US\$/lb., quarterly averages.

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