Critical Metals
For a Sustainable World

Capitalight Research Inc.

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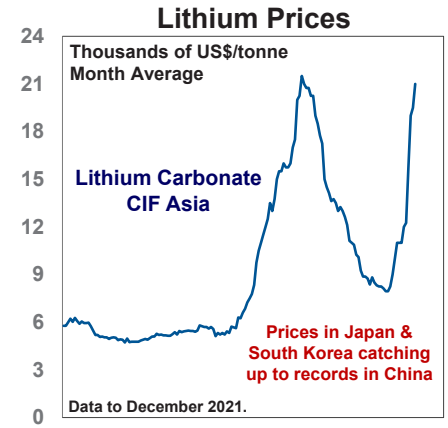
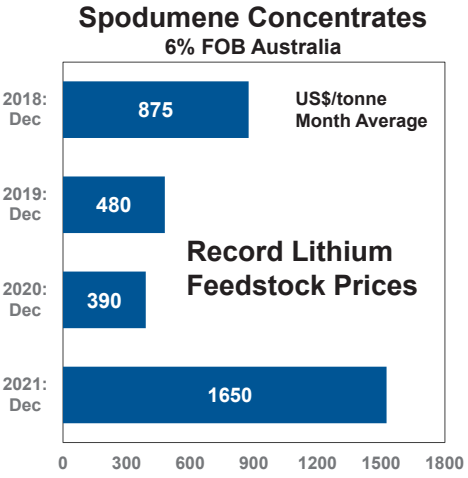


Source: BMI, Bloomberg, Capitalight Research.



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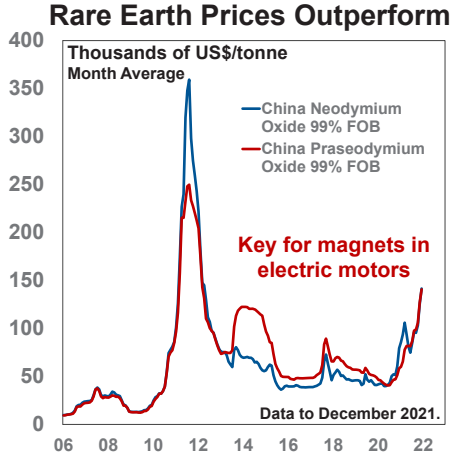
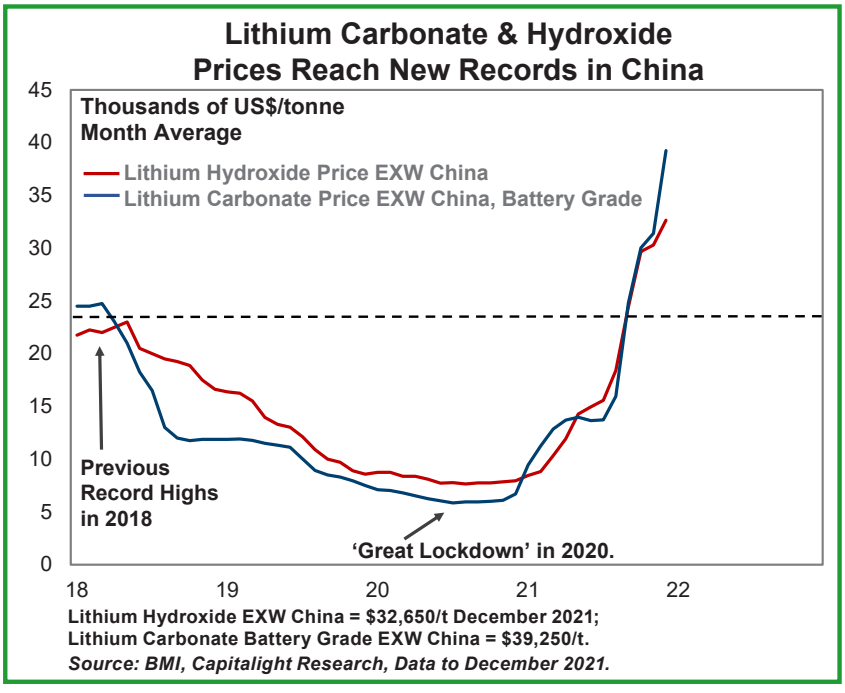


Source: Asian Metals Inc, Bloomberg, Capitalight Research.

- **Lithium carbonate prices reach new record highs in China, with further gains expected in the first-half of 2022;**
- **China consolidates its rare earth industry;**
- **LME nickel prices surge to ten-year high.**

World Supply & Demand Balance for Lithium in 'Deficit' Position

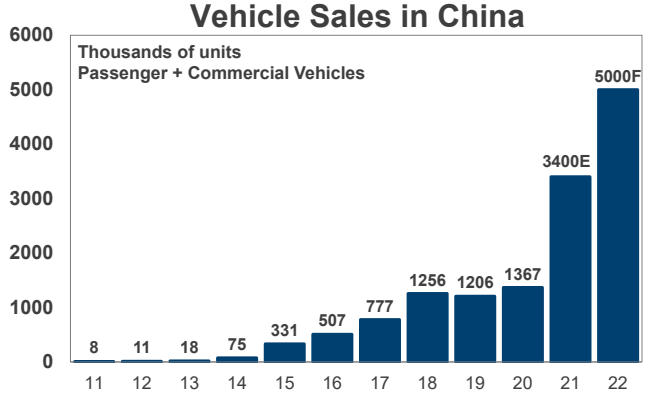
Prices for lithium carbonate & hydroxide in China's domestic market rose to new records in late December 2021, with mid-point prices at US$39,250 and US$32,650 per tonne EXW China respectively – as assessed by Benchmark Mineral Intelligence (BMI). Current prices are up an extraordinary 4.15 and 3.86 times January 2021 levels and are well above the previous record highs in early 2018 – prior to the downturn from Spring 2018 through much of 2020 (please see the chart below). Converters in China have near-zero inventories of lithium carbonate and have been trying to rebuild stocks ahead of China's Spring Festival (the week-long Lunar New Year holiday, that begins on February 1) – despite little uncontracted spodumene feedstock at mines in Western Australia (a key source of hard-rock supplies).



The global supply & demand balance for lithium carbonate equivalent (LCE) probably turned into a 'deficit' position in 2021, after a significant 'surplus' during the 'Great Lockdown' of 2020, when many of the world's advanced economies were shut down. Global market conditions are expected to remain tight in the first half of 2022, with significant new mine supply for converters not expected until the second half of the year.

Looking at demand, the global lithium market was still fairly small at roughly 342,000 tonnes LCE in 2020, but strengthened markedly to about 505,000 tonnes in 2021 (+48%) alongside a 'liftoff' in EV sales in China, Europe and the United Kingdom (data source S&P Global Platts). Demand for battery-driven consumer electronics, energy storage systems (ESS) and industrial goods using specialty/technical-grade lithium (glass, ceramics & lubricants) likely also benefitted from last year's massive monetary & fiscal stimulus by G7 countries – to lift their economies out of the pandemic and build-back better with low-carbon energy.

Prospects appear good for a continuation of robust lithium demand in 2022—likely headed towards at least 650,000 tonnes LCE. The China Association of Automobile Manufacturers expects New Energy Vehicle (NEV) sales in China to climb to 5 million units in 2022 from an estimated 3.4 million in 2021 – reaching 18% of projected overall vehicle sales of 27.5 million (passenger & commercial units). NEV sales could be even larger in 2022 – close to 6 million, with Chinese consumers taking advantage of government incentives before they expire at the end of 2022. China will likely achieve, ahead of time, its target NEV market share of 20% by 2025.



NEVs: Battery electric vehicles, Plug-in hybrid vehicles and Hydrogen-powered vehicles.

Source: China Association of Automobile Manufacturers (CAAM).

The large government subsidies which propelled EV sales in Germany, France and Italy in 2021 have also been largely extended into 2022. Germany will continue to provide a maximum subsidy of €9,000 (US$10,198) for the purchase of a fully-electric vehicle (BEV) and France will provide a maximum €6,000 (US$6,800) until July 2022. Italy has scaled back its 'Ecobonus' incentives, but introduced another e-mobility funding budget in October 2021.

Adding to lithium demand, Albemarle (one of the world's 'Big Four' lithium & specialty chemical producers – the others are Gangfeng, SQM and Tianqi) expects an increase in average EV battery size (from 40 kWh in 2020 to 61 kWh by 2025 and ultimately to 71 kWh by 2030).

On the supply side, the big turnaround in demand in 2021 allowed a gradual re-start of some mine capacity curtailed during the 2018-20 downturn (including 600,000 tonnes at CGP2, Greenbushes Australia – the world's biggest hard-rock lithium mine). Further restarts are expected in 2022. However, Pilbara Minerals recently reduced its spodumene concentrate production guidance for 2021:Q4 and fiscal year 2021-22 due to Covid-related border closures in Western Australia (set to end on Feb 5, 2022), which have reduced available construction personnel. These challenges will delay its ability to improve operations at the Pilgan plant and restart the Ngungaju operation.

In 2022, the following projects and companies are set to increase production, though most will occur in the second half of the year – Albemarle

at La Negra III and IV projects in Chile (in the first half), the Tailings Retreatment Plant at Greenbushes (280,000 tonnes of concentrates), additional SQM LCE from brine in Chile, Olaroz Stage 2 (LCE from Allkem's brine in Argentina) and the restart of one of three processing lines at Wodgina – a joint venture between Albemarle and Mineral Resources in Western Australia. Two new projects should be commissioned in 2022: H2 – Lithium America's 40,000 tpy carbonate operation in Argentina and Sigma Lithium's 330,000 tpy spodumene project in Brazil.

New lithium hydroxide plants will also start up in Western Australia: the Kwinana plant connected to Greenbushes (2 trains totalling 48,000 tpy) and a second plant at Kemerton (a joint venture between Mineral Resources and Albemarle).

Longer-term, substantial expansion at Greenbushes and by SQM, Albemarle & others in Chile's Salar de Atacama is likely and Liontown Resources will move ahead with its large project in Australia. Core Lithium also made a final investment decision to proceed with the Finniss Lithium project in Australia last year. New brine projects in the United States (Standard Lithium & Anson Resources) and Canada, using innovative 'Direct Lithium Extraction' technologies, are likely.

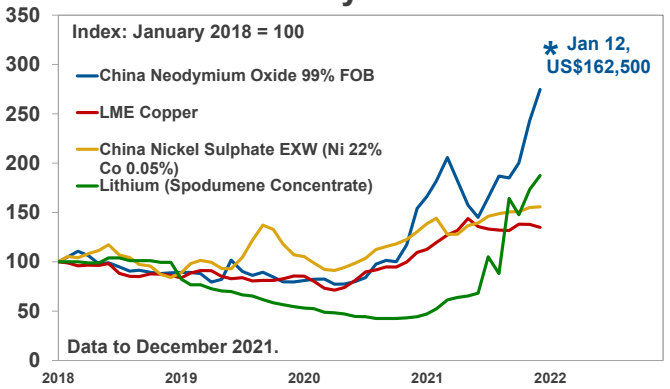
With prices at record highs in China, a number of observers have wondered if the market is ready to correct, as it did in 2018-20. Our answer – this seems unlikely in 2022. The dynamics which caused the downturn in 2018-19 appear to have been a temporary stall in China's EV sales in what was still a small lithium market – just as lithium mine supply was ramped up substantially in Western Australia and Brazil (four new mines were started) and expanded at existing brine operations. New mine supply got ahead of demand. However, last year's 'explosion' in investment plans for new battery megafactories in Europe and the United States combined with an apparent 'liftoff' in global EV sales has probably raised confidence in the durability and size of the EV market.

Lithium prices could retreat temporarily in 2023, if consumers cut EV purchases as incentives expire. However, it is not apparent where all the lithium will come from to supply the huge increase in planned battery plant requirements over the medium to long term. Auto-OEMs have not identified the source.

Canadian Lithium Projects

Canada currently has no operating lithium mines, though two new projects are well advanced and have a good chance of development – James Bay Lithium in Quebec, an Allkem (Galaxy Resources & Orocobre) project with low carbon power from Hydro Quebec; construction may begin in 2022:Q3, with commissioning in 2024, and the Clearwater Lithium Project of E3 Metals – a brine project using proprietary 'Direct Lithium Extraction' technology north of Calgary. Avalon Advanced Materials also continues to advance its Separation Rapids Lithium Project in Ontario – a petalite/lepidolite resource suitable for high-strength glass & ceramics markets as well as battery production – possibly connected to a new refinery in Thunder Bay.

Extraordinary Price Gains for Battery/EV Metals



**Neodymium Oxide, January 12, 2022: US$162,500/t.*

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

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

The E3 Metals project is quite interesting; it will recover lithium from the Leduc aquifer and, after a pilot project, plans to produce 20,000 tpy of lithium hydroxide by 2025-26 (with potential for 150,000 tpy). The project could be one of the largest lithium 'resources' in the world; its technology may be applicable to other aquifers in Alberta.

Battery Chemistries: LFP versus NCM/NCA

LFP battery chemistries enjoyed a stunning resurgence in market share last year in China. Lithium iron phosphate batteries accounted for 56% of China's total battery production in the January to November period – up from only 42% over the same period of 2020. LFP battery output at 105.3 GWh exceeded that of NCM/NCA (nickel cobalt manganese/nickel cobalt aluminium) ternary production at 82.4 GWh.

Two factors accounted for this rebound in market share – firstly, the need to contain battery costs, as Beijing will only provide sales subsidies for vehicles below a certain price point and nickel & cobalt sulphate costs have surged in NCM/NCA cathodes; and secondly, major technical improvements made by electric carmaker BYD and China's largest battery producer CATL. Of note, Tesla has adopted cheaper LFP batteries (especially for its Chinese sales), CATL supplies Tesla with LFP batteries and the Tesla 3 model is a top seller in China.

While LFP batteries are less powerful than NCM chemistries and have a lower range, LFP chemistries are generally safer and last longer; they can also be charged to 100% of capacity without damaging the battery, rather than the 80-90% preferred for NCM. CATL has recently managed to significantly increase the energy density of its LFP battery systems.

The question now is – will LFP also gain market share in the United States and Europe? NCM/NCA chemistries currently dominate OEM plans in the U.S. and Europe and the build-out of battery capacity is just beginning. There is currently no LFP cathode production capacity in Europe.

However, major South Korean battery makers have expressed an interest in LFP batteries as well as nickel-rich chemistries. Tesla will offer buyers the option for LFP in the Model 3 and we expect that LFP will gain market share in delivery vans in the U.S. and Europe, involving slow city driving. ESS storage systems are also set to use LFP batteries due to their greater safety. Nevertheless, NCM/NCA chemistries are likely to retain a majority of the market share in EVs – well over 60% in coming years, probably closer to 80%.

It should be noted that the cost advantage of LFP batteries in China has recently been eroded, as the price of lithium carbonate has moved over hydroxide (see chart on front cover). Lithium carbonate EXW China now trades at a US$6,600 per tonne premium over hydroxide. NCM cathodes with a nickel content greater than 0.6 (NCM 622 and 811) require hydroxide.

Copper Prices Remain Above US$4

LME cash copper prices were US$4.33 per pound in December 2021 – averaging a lucrative US$4.22 for 2021 as a whole – up from US$2.80

Copper Prices Remain Exceptionally Lucrative in Early 2022

* Intra-day record high; January 12, 2022: US$4.51.

Source: LME, Bloomberg, Capitalight Research.

in 2020 during the 'Great Lockdown'. Copper averaged a modest US$2.84 in 2018-19.

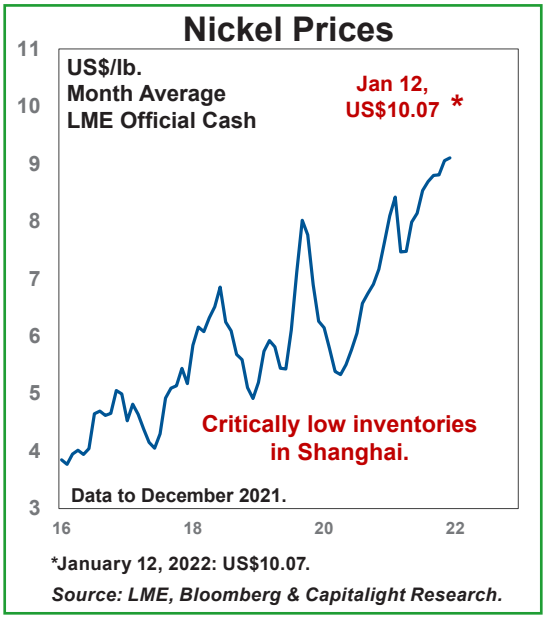
Prices eased back briefly on January 6 to US$4.33, following release of Federal Reserve Board FOMC minutes for December 14-15, showing Fed officials discussing how a strong economy, tight job market and unabated inflation might require Fed funds rate hikes sooner than expected (in June 2022 rather than 2023:Q1). While equity markets were roiled for several days and U.S. 10-year Treasury bonds backed up to a high of 1.80%, financial markets have steadied in recent days and copper prices have rebounded to US$4.38 (January 11).

Looking at U.S. economic indicators more closely, U.S. nonfarm payroll employment only edged up by 199,000 in December, but the unemployment rate fell to a mere 3.9% – near the full-employment rate of 3.5% in February 2020 (just before the pandemic). The PCE Price Index (the Fed's preferred indicator of inflation) climbed by 5.7% y/y in November from virtually zero a year earlier. The Consumer Price Index (released on January 12) rose by 7.0% y/y in December, the fastest pace since 1982.

While a higher U.S. Fed funds rate appears in the cards over the next six months (75-100 bps), copper prices will likely hold up well. Copper will continue to be underpinned by its expanding role in electrification and e-mobility. Trafigura also points to 'critically low' stocks. 'Visible' exchange inventories on the LME, COMEX and Shanghai Futures Exchange represent a mere 5.1 days of consumption.

Nickel: Tesla Arranges Supply With Talon Metal

LME nickel prices surged to US$10.07 per pound (US$22,200 per tonne) on January 12 – a price level not seen since August 2011. The global supply & demand balance for nickel was in 'deficit' in 2021 amid strong nickel-containing stainless steel consumption, a big increase in



demand for nickel-rich batteries and delays in new mine supplies (especially from Indonesia). Nickel matte production in Indonesia is starting to come on stream, with the conversion of some nickel pig iron – normally destined for stainless steel – to matte for use in making battery-grade nickel sulphate. However, the overall market will probably remain in 'deficit' in the first half of 2022.

Top producer Indonesia is reportedly considering taxing nickel pig iron and ferronickel in an attempt to move up the value-added chain with its resources. Indonesia had already prohibited the construction of additional nickel pig iron and ferronickel projects last year.

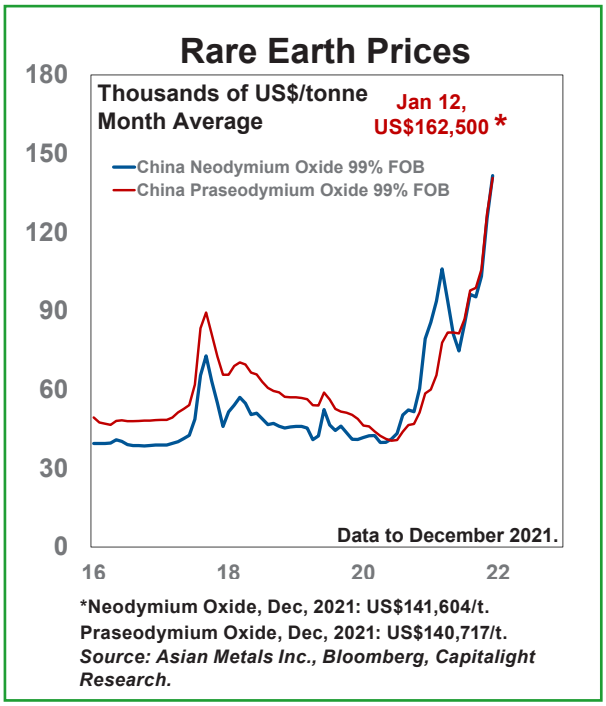
In the meantime, stocks of nickel at the Shanghai Futures Exchange are critically low (about 4,500 tonnes). 'Visible' exchange stocks have plunged by 58.6% y/y.

Tesla has arranged another nickel offtake agreement – this time with a joint venture between Talon Metals and Rio Tinto. The Tamarack project in Minnesota will supply 75,000 tonnes of nickel concentrate over a six-year period.

Rare Earth Prices Continue To Outperform

Prices for light rare earth elements – key for permanent magnets for electric motors and generators for wind turbines – ended 2021 on a strong note. Neodymium oxide jumped from US$125,255 per tonne in November to US$141,604 in December (up 78.4% y/y). Similarly praseodymium oxide climbed from US$127,109 per tonne in November to US$140,717 in December (140.2%). While heavy rare earth – dysprosium oxide – edged down to US$456.6 per kilogram in late 2021, prices were still 56.4% above a year earlier. REE prices have spiked further in January.

China's government has recently moved to consolidate its rare earth sector. The rare earth operations of three major state-owned companies have been merged – China Minmetals Rare Earth Co., Chinalco Rare Earth & Metal Co. and China Southern Rare Earth Group (plus several additional players). The new entity is called China Rare Earth Group and will hold about 70% of China's annual heavy rare earth output allocation. China Northern Rare Earth Group (the world's largest REE miner) will remain the other major producer, with its mined output concentrated in light rare earths.



*Neodymium Oxide, Dec, 2021: US$141,604/t.
Praseodymium Oxide, Dec, 2021: US$140,717/t.
Source: Asian Metals Inc., Bloomberg, Capitalight Research.

China's consolidation is probably intended to bolster control and cost competitiveness, given the intention of the United States and Europe to reduce their dependence on Chinese supplies for these vital minerals and deepen their REE processing abilities (including separating REE oxides). Canada can play an important role in developing alternative, secure supplies of these 'critical minerals' for its trading partners.

Table 1

Critical Metals - Price Trends

	2018 Annual	2019 Annual	2020 Annual	2020 Q4	2021 Q1	2021 Q2	2021 Q3	2021 Q4	Latest Jan 12
Copper									
LME Copper Official Cash Settlement[1] (US$/lb)	2.96	2.72	2.80	3.25	3.85	4.40	4.25	4.40	4.51
Nickel									
LME Nickel Official Cash Settlement[2] (US$/lb)	5.95	6.31	6.25	7.23	7.99	7.87	8.68	8.99	10.07
SHFE Nickel, Generic First Contract[2] (CNY/tonne)	102,916	110,746	109,054	120,402	131,120	128,570	143,708	147,198	162,410
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	39,720	37,750
Lithium									
Lithium Carbonate, CIF Asia ≥ 99.2% Li_2CO_3[3] (US$/tonne)	17,063	11,675	8,421	8,008	9,083	11,000	13,333	19,833	21,000 (Data to Dec 30)
Lithium Carbonate, CIF North America ≥ 99.0% Li_2CO_3[3] (US$/tonne)	14,833	11,215	7,746	7,183	8,083	9,750	12,375	17,000	18,500 (to Dec 30)
Lithium Hydroxide, FOB North America ≥ 55.0% LiOH[3] (US$/tonne)	16,771	13,521	10,629	10,183	10,458	11,750	14,333	19,333	20,000 (to Dec 30)
Spodumene Concentrate, FOB Australia 6% Li_2O, Lithium Feedstock[3] (US$/tonne)	886	595	406	382	472	579	1,048	1,492	1,650 (to Dec 30)
Rare Earth Elements									
China Neodymium Oxide 99%, FOB[4] (US$/tonne)	49,918	44,655	48,757	63,810	95,147	83,222	92,267	123,356	162,500
China Neodymium Metal 99% FOB[4] (US$/kilogram)	64	57	62	80	116	102	115	153	197
China Praseodymium Oxide 99%, FOB[4] (US$/tonne)	63,627	54,024	45,725	52,274	67,818	81,665	94,484	124,540	142,000
China Praseodymium Metal 99% FOB[4] (US$/kilogram)	114	103	91	92	96	104	110	139	163
China Dysprosium Oxide 99%, FOB[4] (US$/kilogram)	177	234	259	266	384	398	400	447	469
China Dysprosium Metal 99% FOB[4] (US$/kilogram)	262	307	341	348	497	516	516	554	580
China Terbium Oxide 99.9% FOB[4] (US$/kilogram)	455	503	664	848	1,382	1,121	1,213	1,600	1,975
China Terbium Metal 99% FOB[4] (US$/kilogram)	604	655	849	1,079	1753	1,430	1,534	2,038	2,550

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	2021A	2022F
2.96	2.72	2.80	4.22	4.20

Copper Quarterly Averages

		Actual													
		20-1	20-2	20-3	20-4	21-1	21-2	21-3	21-4	22-1	22-2	22-3	22-4	23-1	23-2
		2.56	2.42	2.96	3.25	3.85	4.40	4.25	4.40						
Sensitivities	**High**									4.55	4.75	4.30	4.00	4.00	4.00
	Base									**4.35**	**4.50**	**4.10**	**3.85**	**3.85**	**3.85**
	Low									4.15	4.25	3.90	3.70	3.70	3.70
Probability	**High**									0.15	0.15	0.20	0.20	0.20	0.20
	Base									0.70	0.70	0.60	0.60	0.60	0.60
	Low									0.15	0.15	0.20	0.20	0.20	0.20
Probability-Weighted Forecast										**4.35**	**4.50**	**4.10**	**3.85**	**3.85**	**3.85**

LME official cash settlement, US$/lb., quarterly averages.

Nickel Price Outlook - Annual Averages

pre-pandemic				
2018	2019	2020	2021A	2022F
5.95	6.31	6.25	8.38	9.25

Nickel Quarterly Averages

		Actual													
		20-1	20-2	20-3	20-4	21-1	21-2	21-3	21-4	22-1	22-2	22-3	22-4	23-1	23-2
		5.77	5.53	6.46	7.23	7.99	7.87	8.68	8.99						
Sensitivities	**High**									10.25	10.50	10.25	10.00	9.00	9.00
	Base									**9.25**	**9.50**	**9.25**	**9.00**	**8.75**	**8.50**
	Low									8.25	8.50	8.25	8.00	8.50	8.00
Probability	**High**									0.21	0.21	0.21	0.22	0.23	0.22
	Base									0.58	0.58	0.58	0.55	0.55	0.56
	Low									0.21	0.21	0.21	0.23	0.22	0.22
Probability-Weighted Forecast										**9.25**	**9.50**	**9.25**	**9.00**	**8.75**	**8.50**

LME official cash settlement, US$/lb., quarterly averages.

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