

Ken Heebner, the famous Boston fund manager who operated Capital Growth Management until recently, commissioned us to prepare this lithium refining study.

LITHIUM REFINING GLOBAL CAPACITY EX-CHINA SURPLUS IN 2026-28

- In 2022 to 2025 we estimate Western Economies, or the Ex-China global balance, had a refined lithium hydroxide or lithium carbonate equivalent deficit of 99,300 t or 24.4% for 2022, 147,600 t or 29.8% for 2023, 160,700 t or 27.5% for 2024 and 20,800 t or 3% for 2025 (Table 2 on p. 3). That is, the U.S., EU and other nations must import refined lithium from China.
- However, a plethora of lithium refining plants will be built in the U.S., Australia, Chile, Argentina or elsewhere to quintuple Ex-China Li refining capacity from 307,900 t in 2022 to our estimate of 1.53 mmt in 2028 (Table 2).
- We estimate Ex-China economies become self-sufficient in 2026-28 with a refined lithium surplus in 2026 of 186,000 t or 23%, in 2027 a surplus of 312,900 t or 33.6% and in 2028 a refined lithium surplus of 469,900 t or 44.1%.
- More projects are being announced, but it is possible that some are postponed or cancelled if lithium prices fall or a consensus of a market surplus evolves.
- The U.S.-only share of lithium refining capacity is miniscule near 1% in 2022, but it will increase to under 10% of world capacity or about 14% of Ex-China capacity by 2028. U.S. lithium refining capacity in 2027 or 2028 may support up to 10% of U.S. light vehicle output.
- While the global EV industry needs to import refined lithium from China in 2022 to 2025, by 2026 to 2028 the U.S. will be able to shift its import dependence from China to Chile, Argentina, Australia, Indonesia or elsewhere.
- After we tabulated over 80 new proposed lithium mines (see pages 10 to 25), we concluded the spodumene concentrate surplus forcing declines in spot lithium concentrate prices since October 2022 was massive and overwhelming.
- Instead, we shifted our focus of this report to the lithium refining capacity outside of China to make upgraded lithium hydroxide or lithium carbonate equivalents rather than spodumene concentrates.

A SIMPLIFYING APPROACH FOR EV DEMAND FOR LITHIUM

The Australian Government Department of Industry, Science and Resources March 2023 publication is highly professional and helpful. It reviews the several largest Australian mining export industries export volume and price outlooks to guide policymakers to estimate future tax receipts much like the annual copper price forecast of the Chilean Copper Commission, Cochilco. Because Australia accounts for almost ½ of world lithium mine output in 2021 and 2022, its local companies should have a pulse on markets. <https://www.industry.gov.au/sites/default/files/2023-04/resources-and-energy-quarterly-march-2023.pdf>

Thus, we did not attempt to estimate world vehicle output, the EV mix or world economic trends. Instead, we simply used the March 2023 Australian

Industry, Science and Resources agency forecast in Table 1 below. While we simplify our task accepting Australia's national agency, we discuss auto market uncertainty.

Table 1: Lithium Carbonate-Equivalent World Mine Output Forecast											
World	Unit	2022	2023 f	2024 f	2025 f	2026 z	2027 z	2028 z	CAGR r		
Production a	kt	737	964	1,167	1,382	1,646	1,892	2,067	18.7		
Demand b	kt	814	989	1,169	1,373	1,620	1,860	2,130	17.4		
Spodumene price											
– nominal	US\$/t	3,005	4,353	2,824	1,811	2,205	2,700	2,700	-1.8		
– real c	US\$/t	3,110	4,353	2,762	1,736	2,072	2,486	2,436	-4.0		
Lithium hydroxide price											
– nominal	US\$/t	42,601	61,520	43,898	33,390	38,273	42,305	40,140	-1.0		
– real c	US\$/t	44,095	61,520	42,939	32,007	35,963	38,955	36,222	-3.2		
Australia	Unit	2021–22	2022–23f	2023–24f	2024–25f	2025–26z	2026–27z	2027–28z	CAGR r		
Production											
– mine a	kt	333	431	502	562	609	639	661	12.1		
Export volume d	kt	2 248	3 080	3 389	3 794	4 111	4 314	4 462	12.1		
– nominal value g	A\$m	4,899	18,598	19,409	12,692	13,347	20,536	22,090	28.5		
– real value h	A\$m	5,253	18,598	18,560	11,763	12,047	18,083	18,977	23.9		
Notes:											
a Lithium carbonate equivalent: this is a measure of the quantity of refined product.											
b Demand is ahead of consumption by approximately 12 months due to the lead time required in battery manufacturing.											
c In current calendar year US dollars											
d Includes spodumene concentrate exported - mostly 6% Li2O concentrate - plus spodumene concentrate used to produce lithium hydroxide for export											
f Forecast.											
g Revenue from spodumene concentrate and lithium hydroxide											
h In current financial year Australian dollars.											
r Compound annual growth rate (per cent), for the period from 2022 to 2028 or for the equivalent financial years.											
z Projection.											
Sources: Company reports; Dept of Industry, Science and Resources; Wood Mackenzie; Govt of W.Aust. Dept of Mines, Ind. Regulation and Safety											
Source: Australian Govt Dept of Industry, Science and Resources, March 2023											
https://www.industry.gov.au/sites/default/files/2023-04/resources-and-energy-quarterly-march-2023.pdf											

It estimates that EVs grow from a 10% world market share in 2022 to a 30% share in 2028, our furthest distant forecasting year, and 41% in 2032.

Many uncertainties surround the rate of growth of EV penetration. We estimate that cobalt inputs to the battery pack suffer the greatest shortage or least new supply. We estimate that electricity and green electricity shortages exist in most of the world, where California or New Jersey suffer blackouts occasionally today and the Kakhovka dam and Zaporizhzhia nuclear outages deprive 7,550 MW of generation impacting Eastern Europe. Finally, virtually no aluminum new capacity additions are likely globally due to electricity shortages and rising long-term power contract prices, where aluminum-intensive lighter EVs extend driving ranges. Thus, we question whether EVs ever will exceed 50% of the world vehicle market due to shortages of other inputs.

There also are uncertainties about components of the battery supply chain. Diverse infrastructures must be added, including (a) lithium refining capacity, (b) battery charging locations, (c) battery plants, (d) cathode plants and (e) mines. Undersupply of any ONE ELEMENT or PHASE of infrastructure will constrain EV growth.

Table 2: Lithium Carbonate-Equivalent Ex-China Refined Output Forecast

Ex-China Refined (a)	Unit	2022	2023	2024	2025	2026	2027	2028	CAGR	Location	
Lithium Carbonate Demand(a)	kt	407.2	494.5	584.7	686.4	810.1	929.8	1064.9	17.4%		
EXCLUDES Albemarle in China	kt	58	65	135	135	135	135	135		Chendu, Meishan, Xinyu, Qinzhou	
Albermarle	kt	10	10	10	10	10	10	10		La Negra, Chile	
Albermarle	kt	22	25	25	25	25	25	25		Kwinana, WA	
Albermarle	kt				0	30	50	75		Richburg, SC	
Albermarle	kt							20		Kings Mountain, NC	
Albermarle	kt				20	20	20	40		planned EU	
Albermarle	kt						20	40		planned APAC	
SQM	kt	156.8	180	180	200	210	210	210		Chile	
SQM & Wesfarmers JV Covalent	kt					20	40	50		Kwinana, WA from 5.5% Spudomene	
Pilbara Minerals 18% - Posco JV	kt			10	21.5	43	43	43		South Korea; mostly sells Spudomene	
Mineral Resources	kt	60	60	80	90	100	110	120		Western Australia	
Allkem to merge with Livent	kt	20	20	20	42.5	42.5	42.5	42.5		Argentina	
Livent formerly FMC	kt	20	20	20	42.5	42.5	60	60		Argentina	
Livent formerly FMC	kt	10	10	15	15	15	15	15		North Carolina	
Sigma Lithium	kt	0	0	0	0	0	0	0		Brazil to sell concentrate	
Lithium Americas	kt			20	40	40	40	40		Argentina	
Piedmont Lithium	kt					20	50	60		Tenn & NC;\$141.7 mm grant US DOE	
Standard Lithium	kt					6	6	36		Arkansas reaches 51,000 t by 2030	
BASF	kt						20	30		Kwinana, WA no details	
Tianqi Lithium and IGO	kt	1	12	24	24	48	48	48		Kwinana, WA from Greenbushes mine	
TMRC/USA Rare Earth	kt				0	0	0	0		to outsource to third party	
Tesla to supply 1 mm cars	kt				20	60	60	60		Corpus Christi, TX broke ground 5-8-23	
European Li & Obeikan JV	kt				10.1	10.1	10.1	10.1		Saudi Arabia	
Vulcan Energy & Nobian GmbH	kt				15	15	40	40		Hoest, Germany	
Rock Tech Lithium	kt					24	24	24		Guben, Germany	
Sibanye-Stillwater	kt					10	15	15		Kokkola, Finland	
Indonesian government	kt					Pending details				Morowali, Suliwesi	
Lithium Power International	kt							15.2		Chile subject to national policy	
Chengxin Lithium	kt				60	60	60	60		Morowali, Suliwesi	
Tsingshan Holding & Chengxin Li	kt					65	65	65		Indonesia	
Tsingshan, Eramet, Jiangsu	kt						24	75		Argentina	
Cornish Lithium	kt						10	21		Trelavour, Cornwall, UK	
Rio Tinto	kt					5	5	5		Boron, California	
Gangfeng Lithium	kt					30	60	100		Cauchari-Olaroz, Argentina	
All Recyclers, combined	kt	8.1	9.9	20	30	45	60	80		mostly USA and Europe	
Subtotal, Estimated Refining	kt	307.9	346.9	414.0	655.6	986.1	1232.6	1524.8			
Shortfall reliant on China	kt	99.3	147.6	160.7	20.8	-186.0	-312.9	-469.9			
Shortfall reliant on China	%	24.4%	29.8%	27.5%	3.0%	-23.0%	-33.6%	-44.1%			

a. Estimate 1/2 of global demand forecast of Australian Govt Dept of Industry, Science and Resources, March 2023

b. We exclude any Chinese refining or spudomene concentrates. We include Li carbonate equiv., Li hydroxide or recycled batteries

Sources: Company reports or websites; financial press; Australian Govt Dept of Industry, Science and Resources March 2023

Table 3: U.S. Only Li Refining < 10% U.S. Vehicle Output

Li Carbonate Equivalent	Unit	2022	2023	2024	2025	2026	2027	2028	
U.S. LCE Refining	kt	12.7	13.3	21.7	45.0	121.0	156.0	222.7	
5.32 lbs LCE = 1b metal and 5 kg/car		478	500	815	1,692	4,549	5,865	8,371	
Sources: Company reports or websites; financial press; JTVIR, LLC estimates									

Considerable uncertainty surrounds both the sizes of the world total, Chinese and Ex-China vehicle markets. Peaks occurred at 94.4 mm vehicles in 2017 with China at 30 mm and Ex-China at 64 mm units. In 2020-23 volumes average about 80 mm worldwide with China rebounding to 27 mm in 2022 and Ex-China near 50 mm due to pandemic, semiconductor chip shortages, rising car prices and inflation eroding consumer purchasing power globally.

Consumer tastes may vary. EV driving range limits, charge time requirements or impacts to vehicle life may discourage some consumers from adopting EVs. The urban, short distance market is ideal both for EVs, mass transit, bicycles or walking competitively. The rural long distance market is better suited to ICE engines currently. Yours truly rejected the Mustang Mach E when shopping several years ago as its driving range was insufficient for a day trip from the Jersey Shore to a Pittsburgh Steeler game 360 miles west, where my “short distance” car is a restored 1995 Mustang convertible.

AMOUNT OF LITHIUM ESTIMATED 5 KG FOR EACH EV CAR BATTERY

We estimate 5 kg of lithium metal per EV battery based on the most recent quotation citing Elon Musk in August 2022, but our literature search obtained a range of 5 kg to 63 kg lithium for each lithium car battery from sources dating from 2016 to the present. Several unknowns influence such estimates. First, the composition of EV batteries changes with technology. Second, the composition of EV batteries changes with economics of metals prices and availability. Third, bigger luxury cars need a bigger battery for a larger horsepower engine just as an SUV uses more steel, aluminum, etc. for an 8 rather than 4 cylinder ICE engine.

In 2016-17 after a copper price low, Glencore idled large copper-cobalt mines in DRC for a capital investment and rehabilitation program. Due to that temporary cobalt supply interruption, first-half 2018 LME cobalt prices averaged \$38.43/lb at more than twice the 2023 levels. Subsequently, Tesla and perhaps some other EV manufacturers changed their battery compositions to 8-1-1 Li-Co-Mn from 1-1-1 to greatly reduce cobalt and increase lithium use.

One pound of lithium metal requires 5.32 lbs of lithium carbonate equivalent (LCE). One pound of lithium metal requires 2 to 3 lbs of lithium hydroxide. Some companies report output as the sum of LCE and Li Hydroxide, even though they are unequal purities. This introduces an inaccuracy into our own or possibly the calculations of others as well.

Recently in August 2022 Elon Musk was quoted that Tesla uses 5 kg lithium per battery. <https://www.barrons.com/articles/tesla-electric-vehicle-battery-profits-51660832313> In 2016 it was reported a Tesla Model S used 63 kg of lithium. <https://electrek.co/2016/11/01/breakdown-raw-materials-tesla-batteries-possible-bottleneck/> However, another data source reports an average of 8 kg lithium per vehicle below. [https://blog.evbox.com/ev-battery-weight#:~:text=A%20typical%20EV%20battery%20has,\(138%20pounds\)%20of%20lithium.](https://blog.evbox.com/ev-battery-weight#:~:text=A%20typical%20EV%20battery%20has,(138%20pounds)%20of%20lithium.)

LARGE SUPPLIERS OF SPUDOMENE CONCENTRATES

Several of the world's top ten lithium miners simplify their business to only mine rock, crush, grind and separate via froth floatation to make a 5.5% to 8% spudomene concentrate. Thus, **Pilbara Minerals** in Australia and **Sigma Lithium** in Brazil only make spudomene concentrates, and **Albemarle** upgrades the majority of its output but sells a large fraction as concentrates.

Because spudomene concentrate prices fell sharply from October 2022 peaks while lithium hydroxide prices did not fall as much or have been more stable, some of the companies are changing their emphasis. Many add refining capacity to upgrade concentrates. The websites of Standard Lithium and Piedmont Lithium, which we hosted at our past investor conferences, emphasize refining projects. Piedmont Lithium won a US DOE \$141.7 mm grant for its refinery. On June 7th when we phoned Robert Mintak, the CEO of Standard Lithium, he was in Washington, DC perhaps to apply for a similar grant.

TECHNICAL CHALLENGES FOR NEW LITHIUM MINES

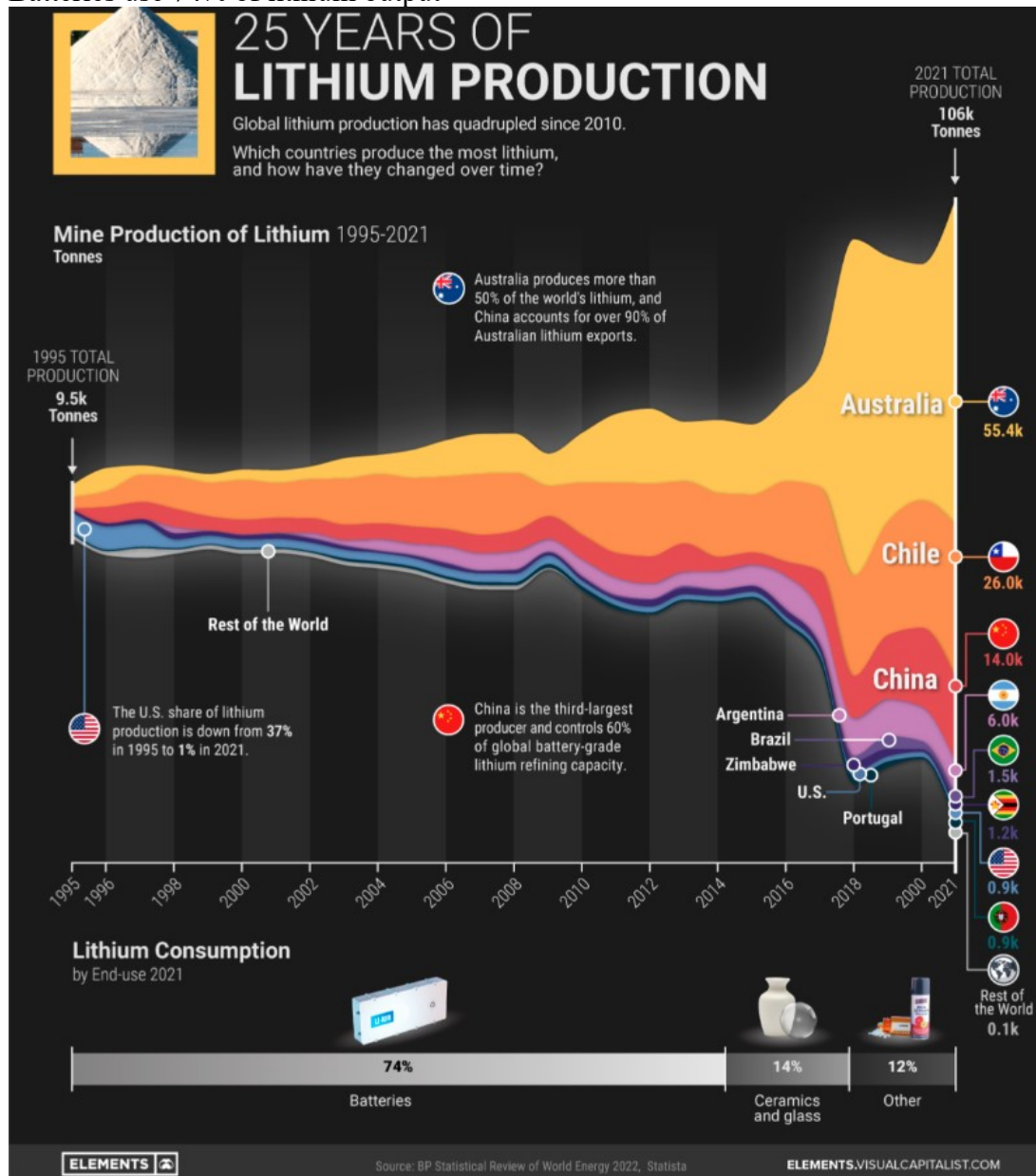
Australia represents nearly ½ of lithium mine output globally, and Australia, Argentina, Chile and China represent 95.6% of historic world lithium mine output (Figure 1 on page 7). We consider the ores in those nations to be well understood. We are confident that a knowledgeable population of miners and metallurgists exist in those 4 nations able to run their mines or refineries competently.

Since 2008 we have hosted 118 mineral companies bought out for US \$103 billion combined at our annual investor conferences, where we take great pride in pre-screening companies prior to presenting them to investors. Our first test is for a US \$3 billion third party verified in situ resource at trough prices, or at least 1 billion pounds of copper, 3 billion pounds of zinc and lead, 3 mm oz of gold, etc.

The two worst submittals we ever received were for a lithium project in Quebec and another in Nevada, where we are extremely skeptical of lithium mine promoters. We rejected Nemaska Lithium because its metallurgical design included an “acid bake” step to pour concentrated sulfuric acid onto ores and then cook them in a furnace, which means it was a very complex molecule to break down. It bankrupted despite over C\$300 mm in subsidies from woke Quebec politicians, and in 2023 the Pallinghurst Group and Investissement Quebec provincial fund own it, promote it and agreed to sell 13,000 tonnes of lithium hydroxide to Ford Motor beginning in 2026. We did not include it in our compendium of new refined supply.

Table 2: 20 Lithium Refining and 14 Recycling Projects Proposed					
					Capacity
Lithium Refining					Li Hydroxide
European Lithium & Obeikan 50%-50% JV				Saudi Arabia	10,129
Vulcan Energy & Nobian GmbH				Hoest, Germany	
Rock Tech Lithium for 2Q 2025 output				Guben, Germany	24,000
Sibanye-Stillwater				Kokkala, Finland	
Indonesian govt concentrator and anode plant				Morowali, Suliwesi	
Piedmont Lithium				Tennessee	
Albemarle				North Carolina	
Albemarle				Antofagasta, Chile	
Pilbara Minerals & Posco				Gwangyang, S. Korea	
Lithium Power Int'l				Chile	
Tsingshan Holding & Chengxin Lithium Group				Indonesia	65,000
Tsingshan Holding, Eramet, Jiangsu Lopal Tech				Argentina	
Cornish Lithium				Trelavour, Cornwall, UK	
Ganfeng Lithium "Hub-and-Spokes" imported conc.				Fengcheng, China	
Tianqi Lithium				Kwinana, Western Australia	
BASF				Kwinana, Western Australia	
Albemarle				Kwinana, Western Australia	
SQM				Kwinana, Western Australia	
Rio Tinto				Boron, California	5,000
Tesla				Austin, Texas	
Lithium Battery Recycling					
Glencore & Li-Cycle (36 GW or 50,000-70,000 t batteries)				Portovesme, Italy	
Glencore, Ambito, Iberdrola				Iberian peninsula	
Redwood Materials				northern Nevada	
Redwood Materials				Charleston, SC	
Cirba Solutions				Lancaster, OH	
Stelco-SMS Group-Neometals				"North America"	
Glencore & Britishvolt				Northfleet, UK	10,000
Glencore & Managem				Morocco	
Battery Resources				Covington, GA	
Retriev Technologies Inc & HOBI Int'l				Lancaster, OH	
Norsk Hydro & Northvolt				Fredrikstad, Norway	8,000
Li-Cycle				Rochester, NY	5,000
Ascend Elements				GA, MA, MI	
BASF and Tenova				Schwarzheide, DE	
Sources: Company Reports; Mining.com; other trade publications					

Figure 1: Lithium mine output 95.6% from Australia, Chile, China and Argentina;
Batteries use 74% of lithium output



Source: <https://elements.visualcapitalist.com/25-years-of-lithium-production-by-country/>

Source: <https://www.weforum.org/agenda/2023/01/chart-countries-produce-lithium-world/>

We later received a submittal from Nevada Lithium, whose September 23, 2021 NI 43-101 technical report calculated 3,407.3 million metric tonnes at 1,013 parts per million or about 2.2 pounds/t LCE or about 0.4 pounds of lithium metal per tonne. It was supported by only 10 drill holes with 435 assays for about 2.5 km drilled spaced at 1 km intervals. We calculated 1 assay for each 3.4 million tonnes of resources, which is the skimpiest data set we ever evaluated after the 2nd skimpiest of 185,000 t/assay for Northern Dynasty in Alaska. Commercial copper mines range from 5,000-15,000 t/assay and gold projects

may be near 100 t/assay. Further, the Qualified Person estimated a 68% mining recovery rate and 5% mining dilution from the skimpy data to make an economic study Preliminary Economic Assessment upon which we hesitated to rely.

Thus, we have a high level of confidence in the new mine projects in Australia, Chile and Argentina that are well proven venues. We will be surprised if ½ of the proposed mines are profitable in the U.S., Quebec or other new regions. In particular, some Nevada projects have miniscule low amounts of lithium or northern Quebec projects are far far from roads or infrastructure, workers in remote fly-in, fly-out mine camps require exorbitant wages and the ore grades or recovery rates may be challenging. Thus, the new mines in North America or other new regions may be the first ones to close if lithium oversupply worsens, prices fall, other materials constraints constrain EV sales such as cobalt or electricity or other challenges evolve.

GEOGRAPHY OF LITHIUM REFINING PROJECT ANNOUNCEMENTS

The first 20 lithium refining project announcements we identify in the trade press since 2021 break down as 4 in Kwinana, Western Australia very near the Alcoa Kwinana, Pinjarra and Wagerup alumina refineries, 4 in the EU, 4 in the USA, 2 in Indonesia, 3 in Chile or Argentina and 1 each in Saudi Arabia, South Korea and China, where 4 of the 20 plants have Chinese partners, co-owners or offtake destinations. Thus, there appears to be a large array of lithium refining capacity outside of China slated to arrive in 2025 to 2028. Fourteen of the 20 refinery projects have large capitalization “household names” as project sponsors, which suggests mostly they are well-financed, well-engineered dependable projects. We increased our compendium of lithium refineries to 33 in Table 2 on page 3 as we traced the existing, expanded or planned new refineries outside of China of the dozen largest capitalization lithium stocks. We read of more every day.

Similarly, we identify 14 lithium-ion battery recycling project announcements. These are quite surprising and aggressive, as the volume of EVs on the road to wear out is relatively new and not too large. It is unknown whether the lithium-ion batteries will wear out in 5, 10 or 20 years or whether their failures will be tied to wear, rates of use, charging temperatures or charging speeds. Seven of the 14 projects also are large capitalization, well-financed household names with 4 from Glencore and one each from BASF, Norsk Hydro and Stelco. Glencore in particular is very eager to control the recycling of cobalt and lithium both to complement its large global position in cobalt, copper and nickel mining also important to EVs and its global trading and mining commodity franchises.

Eight of the 14 battery recycling ventures are in the USA. Another five are in the EU and one in Morocco. We expect another dozen such lithium-ion battery recycling projects in China or Asia, since China is the world leading venue for EV output and sales.

AT LEAST ¼ OF LITHIUM MINE OR REFINERY ANNOUNCEMENTS HAVE CHINESE CONTROL, OWNERS, PARTNERS OR OFFTAKE COMMITMENTS

We have fourteen pages of lithium mine, refinery, battery or other green technology announcements on pages 10 to 25 following. We identify Chinese partners or owners for

Table 3: Lithium Project Breakdowns from Western Press Ex-China

	Roughly 1/4 new mines Chinese-controlled			Chinese-owned Projects		
	New	New	Battery	New	New	Battery
	Mines	Refineries	Recycling	Mines	Refineries	Recycling
June 23	3	1		2		
May 23	1	1	1			
April 23			1			
March 23	1					
Feb 23	3		2	1		
Jan 23	6			1		
Dec 22	10			1		
Nov 22	3	3		1		
Oct 22	5	1	1	1		
Sept 22	1					
Aug 22	3			3		
July 22	1			1		
June 22	5	2				
May 22	3		1			
April 22	5			1		
March 22	2	1				
Feb 22	2		2	1		
Jan 22	1	1	1			
Dec 21	3					
Nov 21	3	3		1	2	
Oct 21		1			1	
Sept 21	1					
Aug 21	1	3		1	1	
July 21	4			1		
June 21	9	1	2	5		
May 21	0	0	0			
April 21	1	1				
March 21	2		1	1		
Feb 21		1				
Jan 21	3			1		
Past 2 1/2 year total	82	20	12	23	4	0
Sources: Company Reports; Mining.com; other trade publications						

23 of the 81 new lithium mine announcements, 4 of 20 refinery announcements and none of the 12 lithium-ion battery recycling announcements.

Of course, Chinese companies already refine lithium, make the batteries and supply the roughly ½ of world EV output manufactured and sold in China. In addition, they strive to control spodumene mine concentrate flows to feed their refineries, battery manufacturers and auto industry.

We are surprised there are no Chinese rush to pursue EV battery recycling, where prominent companies such as Glencore move fast. There are technology uncertainties about the efficiency or purity of recycled EV battery metals. For example, electric arc furnace steelmakers are hypersensitive to minute amounts of copper or tin within their steel scrap charges, as Cu or Sn micro alloy with steel to make steel brittle or not ductile creating cracks. There may be challenges in separating cobalt, lithium, manganese, nickel or graphite within the batteries.

Table 20: Leading Lithium Stocks				
			Price	Market
			6-5-23	Value
				\$ Bil.
Albemarle	ALB		\$207.06	24.4
SQM	SQM		\$68.94	18.5
Gangfeng Lithium	GNENF		\$6.81	17.5
Tianqi Lithium Corp	TQLCF		\$10.70	17.0
Pilbara Minerals	PILBF		\$3.03	9.0
Mineral Resources	MALRF		\$46.57	8.6
Allkem	OROCF		\$9.84	6.4
Livent	LTHM		\$24.51	4.5
Sigma Lithium	SGML		\$40.40	4.2
Lithium Ameicas	LAC		\$20.72	3.4
Piedmont Lithium	PLL		\$61.54	1.2
Standard Lithium	SLI		\$4.24	0.73
Lithium Chile	LTMCF		\$0.61	0.127
European Lithium	EULIF		\$0.06	0.103
Lithium & Boron Tech	LBTI		\$0.0004	0.074
Texas Mineral Res Corp	TMRC		\$0.92	0.069
Lithium Australia	LMMFF		\$0.02	0.029
Lithium Corp	LTUM		\$0.12	0.014
Nevada Lithium	NVLHF		\$0.13	0.0083
Nemaska Lithium	bankrupted			
Yongxing Special Materials	HK Listed			
Sichuan Yahua Industries	HK Listed			
Youngy	HK Listed			
Total Market Values				115.85
Source: John Tumazos Very Ind. Research, LLC Estimates				

LITHIUM MINE PROJECTS BY REGION

We have a high level of confidence that 80%-100% will be successful among 39 of the 80 projects listed, where the salt brine evaporation ponds of Chile's 8, Argentina's 21, 1 in Bolivia or Western Australia's 9 mine projects are well proven and established. We estimate less than 25% of the 19 North American projects will succeed, as their low

grades and complex metallurgies make them highest cost or most risky. We have not studied carefully those 8 in Africa, 10 in Europe or 3 in China.

Table 4: Proposed Lithium Mine Breakdowns by Nation or Region

USA	12	(Majority Nevada very low grade)
Quebec	6	(Complex metallurgy, remote logistics or low grade)
Mexico	1	
Chile	8	Well proven
Argentina	21	Well proven
Bolivia or Brazil	2	
Western Australia	9	Well proven
Europe	10	
China	3	
Africa	8	
Subtotal	80	

Source: Company reports; Mining.com; other trade publications

LITHIUM MINING, RECYCLING OR REFINING PLANT ANNOUNCEMENTS JUNE 2023

- **Tibet Summit Resources** promises \$1.7 billion to develop two lithium mines in Argentina at Arizaro and Diablillos salt flats in Salta province to produce 50,000-100,000 t of lithium.
- **European Lithium** plans a 2,000 mtpd lithium mine about 20 km outside of Wolfsberg, Austria to produce 10,129 mtpd of lithium hydroxide. It reports 6.3 mmt of 1.17% LiO₂. Separately, it formed a 50%-50% JV with Obeikan in Saudi Arabia to build a refinery to source spodumene from Wolfsberg, where the refinery will pay \$3,000-\$7,000/t for spodumene concentrates.

MAY 2023

- **Glencore** and **Li-Cycle** announced a joint venture to complete a 2023 definitive feasibility study a 50,000 to 70,000 t recycling hub based at the former Glencore zinc smelter at Portovesme, Italy on Sardinia island, which has much unused infrastructure as Alcoa shut aluminum as well as Glencore shutting zinc smelting. The Li-Cycle JV targets recycling of Li, Ni and Co from EV batteries. Its goal is to recycle 36 GW of lithium-ion batteries.
- **Vulcan Energy** will invest \$72 mm for its 50% stake in a German lithium recovery plant. The JV is Nobian GmbH at the Hoest Chemical Park. The Central Lithium Plant cap ex budget currently is estimated at euro 332 mm, where the current funding is only a fraction of the estimated capital. The project includes renewable energy, hydrogen output, production of lithium chloride and distribution of products to customers, Presumably debt financing will match the equity funding, and green financings are popular among banks or bond markets.
- **Codelco**, Chile's state copper miner, predicts its Maricunga salt flats lithium exploration is "extraordinarily successful" and will be the 2nd largest lithium concentration in the world.

APRIL 2023

- **Glencore** partnered with waste management firm FCC Ambito and Spanish utility Iberdrola for lithium-battery recycling services in Spain and Portugal. The three

companies have not yet selected a single location to serve the two nations in the Iberian Peninsula. Glencore appears to target a system of 10+ such locations to source scrap from the larger world population centers, where Glencore's marketing and trading units will build in lithium upon their existing relationships as large marketers of cobalt, copper, nickel, chrome and other metals.

- **Syrah Resources** builds a graphite anode plant in Vidalia, Louisiana, where the cap ex budget escalated to US \$539 mm. It will sell to EV battery manufacturing plants now under construction.

MARCH 2023

- **Pure Energy Minerals** and partner **Schlumberger** obtained permits for a "pilot" direct lithium extraction plant at its Clayton Valley lithium brine project in Esmeralda County, NV adjoining Albemarle's producing lithium mine. The pilot plant should provide important information to confirm ore grades, recovery rates, process time cycles and operating costs. Presumably equity or debt investors or directors wanted more reliable data than prior technical studies. After successful pilot tests, then permits for a larger mine, process plant and tailings must be obtained prior to financing and construction. Commercial revenues may be 4 or 5 years away at best.
- **Jervois** halted construction in Idaho on March 29th of its 1,200 mtpd underground mine and mill to produce 1,200 mtpd of cobalt, copper and gold ores. The prior owner had invested \$120 mm to start the project, and Jervois about another \$100 mm. The November 2020 technical report estimated that 2.5 mmt of reserves would be processed over 7 years from a 6.7 mmt resource, which is short lived. At \$25/lb cobalt and mid-pandemic low costs it did not project "payback" until the 5th year of output. It forecast 6 ½ years of output from reserves near 1,800 t Co concentrates, 3,000 t Cu concentrates and 4,000 oz gold within the copper concentrates. The recent plunge to \$15/lb Co prices, Tesla and Ford's EV price cuts, likely higher capital and operating costs than estimated in 2020 and the rise in DRC Cu-Co output where DRC surpasses Peru as the #2 world copper miner combined to hurt the project.

FEBRUARY 2023

- **China Natural Resources** will acquire Williams Minerals to acquire its lithium mineral resources in Zimbabwe for a down payment of \$140 mm and staged future payments to total up to \$1.75 billion. It targets a mid-2023 transaction closing. We estimate it must target 25,000 to 100,000 t of lithium carbonate equivalent annual output by 2026 to invest such large sums.
- **Form Energy** seeks to develop an iron-air battery, exploiting the chemistry of rust or reverse iron oxide. It does not require any rare metals, but iron is heavy. It raised a \$240 mm funding in 2021. Perhaps it is better suited to stationary storage batteries to support wind or solar farms. We observe that Fortescue Metals adds 10% redundant truck, shovel, ore processing, labor and other mining capacity in its battery truck 2026-28 transition to reduce its dependence on storage batteries, where Fortescue will mine more rock when the sun shines and the wind blows.
- **Sibanye-Stillwater** obtained permits for its euro 558 mm Rapasaari mine and Paivaneva concentrator in Kaustinen and refinery in the Kokkola industrial park

- new the existing cobalt refinery. In October it increased to 85% ownership of Keliber, a battery manufacturer, to control these projects.
- **Eramet**, the French nickel miner and smelter in New Caledonia, advances the Centenario lithium project in Argentina. Partnered with Tsingshan of China, they target 24,000 t of annual lithium carbonate output annually starting in 2024 in a first phase. The partners study whether to double or triple output after confirmatory results from the first phase.
 - **Jindalee Resources** of Australia claims its project on the Nevada-Oregon border is the largest lithium resource in the USA. It increased its lithium carbonate contained indicated and inferred resources to 21.5 from 13.3 mmt of lithium carbonate equivalent. It contains 3 billion tonnes at 1,340 lithium carbonate parts per million or g/t, which is near 3 pounds per ton or near 0.15%. It seeks funding under the Inflation Reduction Act.
 - **Redwood Materials** won a \$2.0 billion US DOE loan toward a \$3.5 billion EV battery recycling and remanufacturing complex in northern Nevada. It plans a second similar plant two years later for \$3.5 billion in Charleston, SC. Redwood is headed by a former Tesla executive. We are not familiar with how it will separate lithium, cobalt, graphite or other battery materials.

JANUARY 2023

- **Lithium Americas** obtained \$650 mm in financing pledges from General Motors in exchange for a 10% equity stake and 100% offtake rights from phase one of its Thacker Pass, Nevada mine future output. The project targets 60,000 t annually of lithium carbonate output from 532 mmt containing 8 mmt of lithium carbonate equivalent. The first \$320 mm escrow will be held until full permits, US District Court “record of decision” approval and other conditions. A second \$330 mm tranche releases after the company splits in two, as GM apparently does not want to invest in the Argentine project.
- **Essential Metals**’ 11.2 mmt at 1.16% lithium oxide “Dome North” deposit in Western Australia appears to be economically viable based on the January 9th A\$136 mm takeover bid from Tianqi Lithium Energy Australia JV of Tianqi Lithium and IGO Ltd of Australia. Essential also owns gold and nickel exploration assets.
- **Galaxy Resources** James Bay lithium project won government permit approvals. It boasts 1.4% Li₂O grade and 3.7:1 strip ratio. The company also owns Mt Cattlin mine in Western Australia and Sal de Vida project in Catamarca, Argentina. Both green lithium and “Plan Nord” projects in Quebec are politically expedient to easily breeze through permits, but costs could be much larger than US \$244 mm cap ex or US \$290/t concentrate operating costs estimated in PEA.
- **Cornish Lithium** advances the Twelveheads geothermal lithium project near Chacewater in Cornwall in the extreme southwest peninsula of the UK 202 miles southwest of the port Southampton.
- **Wealth Minerals** published a maiden lithium resource of 1,441,000 t lithium carbonate equivalent grading 180 milliliters/liter at Ollague in 2nd Region of Chile near the Bolivian border. It evaluated an evaporitic basin with geophysics and drilling of its own and prior owners. Development requires access to water resources and environmental approval. It does not appear adjacent to any copper

mines that would compete for water resources or be able to share either desalination infrastructure or ground water.

- **CATL**, a Chinese battery maker, won a competition and was selected by Bolivia's government to mine the Potosi and Oruro salt flats for lithium.

DECEMBER 2022

- **Ioneer** reported that the US BLM will publish a Notice of Intent in the Federal Register to permit its Rhyolite Ridge lithium-boron mine in Nevada. This is a milestone phase under the National Environmental Policy Act (NEPA) towards a permit or future operation, although several years of judicial challenges often follow if environmental groups challenge the documentation or judgements of government agencies. While Ioneer targets 21,000 t of lithium carbonate output annually beginning in 2025 with contracts to deliver 4,000 t to Toyota and 7,000 t to Ford, it could fall a couple years behind that schedule with challenges such as related to the newly designated "endangered" Tiehm's buckwheat flower so classified by the US Fish and Wildlife Service. (BLM, US Forest Service and US Fish and Wildlife Service each are within the US Dept. of Interior). *There are a handful of Nevada lithium projects, all of which fall on Federal lands which up to this point had no Federal political support. However, it is possible that with the emphasis to fund output battery materials in the Inflation Reduction Act the sentiment in Washington changes to support lithium mining.*
- **Sigma Lithium** began commissioning its Grota do Cirilo lithium mine in Minas Gerais, Brazil and hopes to sell commercially in February with full output in April 2023 targeting 36,700 t Li Carbonate Equivalent annually. A later phase may triple output to 104,200 t LCE, but fall in years 9 to 13 to 60,000-65,000 t LCE.
- **Lithium Americas** will acquire Arena Minerals for \$227 mm to control the Pastos Grandes basin in Argentina, which is very near the Cauchari-Olroz lithium brine deposit of Lithium Americas slated to begin output by mid-2023. Lithium Americas will consolidate the two projects, either to expand its project or else extend the reserve life of its project.
- The quarterly report of Australia's Department of Industry, Science and Resources estimates that (<https://www.mining.com/australia-expects-sharp-lithium-price-pullback-in-2024/>) by 2024 Australia's lithium carbonate output equivalent will grow to 470,000 t and represent almost ½ of 2024 global output near 1.1 mmt. Global output averaged 0.2 mmt in 2012-16 and 0.4 mmt in 2017-20, but rose to 551,000 t in 2021 and 691,000 t in 2022. It cited in Australia (1) Mineral Resources & Gangfeng Lithium's Mt Marion, (2) Liontown's Kathleen Valley, (3) Core Lithium's Finnis project near Darwin due for mid-2023 output and outside of Australia brine operations in Chile of (4) SQM, (5) Albemarle, (6) Codelco at Salar de Maricunga just to begin drilling in 2023, in Argentina (7) Allkem, (8) Livent, (9) Minera Exar, (10) Piedmont Lithium in Ghana and (11) in Austria the Wolfsberg project of European Lithium. Only projects #1, 4 and 5 were advanced in our prior data, where projects #3, #6, or #10 may not be fully documented. The Australian agency tabulates both fully documented and exploration activities.

NOVEMBER 2022

- **Rock Tech Lithium** proposes to spend US \$683 mm to refine 24,000 t of Li hydroxide monohydrate over a 25 year life in Guben, Germany. It proposes early

2023 ground-breaking for second-quarter 2025 output. It has a 12 hectare or about 30 acre site in an industrial park. We are not aware of its raw materials or concentrate strategy or whether it has tested its refinery process on ores from Nevada, Bolivia, Argentina, Chile, Australia or elsewhere. Presumably it would refine lithium from miners unwilling to export to China or because it offers better terms.

- **Tsingshan Holdings** signed an agreement with the Zimbabwe government to develop, mine and concentrate the large known lithium deposits in southern Zimbabwe. Tsingshan already has large met coal, ferrochrome and stainless steel operations in Zimbabwe, where it may be the largest taxpayer or contributor to GDP.
- **Sibanye-Stillwater** will spend US \$616 mm near Kokkala, Finland for two open pit lithium mines, a concentrator and a lithium hydroxide refinery.
- Indonesia's government builds a 60,000 t lithium concentrator and 80,000 t anode plant in Morowali industrial park in Sulawesi near existing nickel and cobalt mines and refineries. Indonesia has no lithium mines, where it will import lithium ores to operate multiple battery materials hubs and later seek complete EV battery output.

OCTOBER 2022

- **Atlantic Lithium** will obtain the Ewoyaa lithium project in Ghana from Piedmont Lithium, which is stalled in the Carolinas. It will make phased "earn-in" investments of \$103 mm. It targets 2H 2024 output over 12.5 years for US \$5 billion in revenue. It hopes to process 2 mmt annually in ores perhaps to sell 50,000-100,000 t annually of lithium carbonates.
- **Cirba Solutions** won a \$75 mm DOE grant to build a lithium battery recycling facility in Lancaster, OH sufficient to power up to 200,000 vehicles. Cirba Solutions also builds a smaller such plant in Eloy, AZ sufficient to supply 50,000 vehicles.
- **Syrah Resources** won an up to US \$220 mm US DOE grant to supply graphite from its Vidalia, Louisiana facility to LG Energy Solutions battery plant.
- **Albemarle** won a US \$150 mm grant to develop its North Carolina lithium mine and processing plant. Albemarle is a highly profitable company able to self-fund that did not need a government grant.
- **Piedmont Lithium** won a US \$142 mm grant to develop a lithium refinery in Tennessee initially to process material from Quebec and Ghana. Its North Carolina mine and processing plant suffered delays due to local opposition.
- **Eramet** and **Tsinghan** plan 24,000 t of 2024 lithium output in Argentina at the Centenario deposit, which they study doubling after several years. Eramet seeks more lithium projects in the "neighborhood" bordering Chile, Bolivia and Argentina.

SEPTEMBER 2022

- **YPF**, the Argentine state oil company, launches a 20,000 hectare lithium exploration project in Catamarca province in JV with a local private company.

AUGUST 2022

- **Zijin Mining** targets also the Lakkor Tso lithium project in Tibet, China in phase one with 20,000 t Li Carbonate to expand with 2.14 mmt Li Carbonate-equivalent.
- **Zijin Mining** advances the Dao Xian lithium polymetallic mine in Hunan, China to restart at 30,000 mtpd aiming for 10 mmt with 60,000-70,000 Li Carbonate-equivalent after full expansion.
- **Zijin Mining** plans 2023 startup of its 3Q Salar lithium mine in Argentina at 20,000 t lithium carbonate equivalent output for 2024 in phase one.

JULY 2022

- **Syrah Technologies LLC** obtained a \$102.1 mm loan from the US DOE for a Louisiana plant to make graphite-based active anode material for lithium-ion batteries. Syrah, based in Australia, will process graphite mined in Mozambique. It was the first loan under a 2011 law for advanced auto supply chain materials.
- **Zangge Mining** of China and **Ultra Argentina SRL** will invest \$290 mm for lithium projects in northwest Argentina. Initially Zangge will invest \$40 mm into Laguna Verde lithium project in Catamarca province, where \$250 mm is a budget target for a lithium carbonate plant. Zangge will earn a 65% stake in Ultra Argentina subsidiary of Ultra Lithium for US \$50 mm. Presently two lithium mines operate in Argentina, Orocobre and Livent Corp., but 23 are under study or development.

JUNE 2022

- **Albemarle** dedicated a new third lithium brine recovery plant in Antofagasta, Chile which will double refined lithium carbonate output and reduce water consumption. It cost \$500 mm, and can make value-added products from Salar de Atacama lithium concentrates. This is separate from mining, and reduces the exports of intermediates to China or others and provides a fuller profit to Albemarle.
- **Albemarle** plans a \$1.2+ billion lithium processing plant in the US near 100,000 t LiO₂ large enough to double Albemarle's lithium processing capacity to be sufficient to supply the entire US lithium requirements for EVs. Albemarle's global target is 500,000 t capacity by 2030. Ore feedstocks may come from a restart of Albemarle's idle Kings Mountain, NC mine and Piedmont Lithium's nearby mine under development. Some lithium mines also are under study in Nevada and imported concentrates represent another feedstock alternative.
- **Critical Elements** completed a feasibility study for the "Rose" lithium-tantalum project in the Eeyou-Ischee, James Bay region of Quebec. The province has made abundant past outlays to subsidize both "Plan Nord" or green battery minerals projects in its north. Critical Elements targets 26.3 mmt at 0.87% Li₂O and 138 ppm or 138 g/t or about ¼ lb/t Ta₂O₅ tantalum pentoxide. The company calls these 17 zones "probable reserves" within a model of an 7.3:1 strip ratio for 190 mmt of waste.
- **Piedmont Mining 25%** and **Sayano Mining 75%** will restart the La Corne, Quebec lithium project known as "North American Lithium," where spodumene concentrate output started in 2012 and idled twice in 2014 and 2017 and bankrupted. Today lithium carbonate prices are higher. The budget for the restart is near C\$100 mm. It targets 115,000 t of spodumene 6% LiO₂ concentrate for

27 years. Quebec government financial support is plausible for any “green” project as well.

- **Pilbara Minerals** will invest A\$298 mm or US \$206 mm to add 100,000 t to 680,000 t from 580,000 t spodumene concentrate output annually. It will add a separate circuit to treat low grade waste material for most of the new increased output.

MAY 2022

- **SQM** increased March 2022 quarterly output 59% to 38,100 from 23,900 t of lithium and derivatives last year. Due to price and volume gains, quarterly revenues rose 970% by \$1,311.1 o \$1,446.4 mm from \$135.2 mm last year. SQM is slightly ahead of its 140,000 t target for 2022.
- **Sigma Lithium** claims it will produce 531,000 t of lithium annually for 13 years from two deposits at Grota de Cirilo in Minas Gerais, Brazil. Its April 2022 feasibility study claimed an 8 year life for phase 1. It seeks project financing from Societe Generale SA. *It is possible that lithium supply outstrips other necessary battery or EV metals, such as cobalt or aluminum for all-aluminum EVs to offset the battery weights. We worry less about Ni or Cu, where there are large expansions and substitutions of Cr, Mn or Mo for Ni in stainless steels will free up Ni for the batteries.*
- **Sayona Mining** raised US \$136 mm to restart its 75%-25% JV with Piedmont Lithium in Quebec in 2023. The JV bought the project in 2021, and will integrate it into the 100% Sayona-owned Authier project. It is at the prefeasibility study level with a \$71 mm estimated cap ex need. Its resources are 29.2 mmt at 0.96% Li₂O. The target concentrator throughput is 4,200 mtpd..
- **Stelco** partnered with Primobius GmbH of Germany, in turn a partnership of **SMS Group** and **Neometals Ltd.**, to commercialize to apply the German firm’s EV battery recycling technology in North America.

APRIL 2022

- **Ascend Elements** plans 3 plants in GA, MA and MI to shred lithium-ion batteries, and attempt to separate to recycle and reuse the lithium, cobalt, nickel, graphite and other materials.
- **Sigma Lithium** began laying concrete foundations for phase 1 to 240,000 t at US \$260 mm towards a phase 2 460,000 t of lithium concentrates, which at phase 2 would translate into 66,000 t lithium carbonate equivalent in calendar 2024. The mine is called Grota de Cirilo in Brazil and will have hydroelectric power.
- **Albemarle** and **Mineral Resources** now target May 2022 to restart the Wodgina, WA lithium mine restart towards 0.5 mmt annual ore processing. There are 4 250,000 t trains idle since 2019, where a higher output is possible. In October 2018 the mine was reported at 151.9 mmt probable ore reserves at 1.17% Lithium, where a 0.5 mmt output would equate to about 5,000 t Li or 25,000 t lithium carbonate.
- **Mineral Resources** in a separate 50% JV with **Jiangxi Ganfeng Lithium** makes a one-third expansion tgo the Mt Marion, WA mine from 450,000 t to 600,000 t and may later consider 900,000 t lithium ores. Its reserves were reported 71.3 mmt at 1.37% Li₂O and 1.09% Fe, where expanded it may produce total output at 0.9 mmt ores over 10,000 t Li or 50,000 t Li carbonate annually.

- **Norilsk Nickel** and **Rosatom** will jointly develop the Kolmozerskoye lithium near Murmansk in the Arctic Sea region of northwest Russia. It is unclear how much documentation exists. Argentina and Chile will not ship lithium concentrates to a Russian processing plant due to sanctions, where this announcement could be a “propaganda” response or could be bona fide.
- Canada’s federal budget includes US \$1.6 billion for “battery metals,” but no specific projects nor rational processes for project selection are evident. The Canadian federal and provincial governments are emphatic to turn “green,” where ½ of the costs of converting Algoma Steel in Sault St. Marie and MT’s Dofasco in Hamilton, ONT are government funded. This initiative is not clear but may consider alternatives ranging from battery “gigafactories” to nickel, copper, cobalt, lithium, graphite or other battery minerals or supply chains. *Quebec province funded Nemaska Lithium, Orbite Aluminae, BlackRock iron ore or some others that have consumed large sums without advancing. We worry the government agencies may fund flawed feasibility studies or skimpy data prior to full documentation.*

MARCH 2022

- **Pilbara Minerals** and **Posco** of South Korea collaborate for a \$750 mm lithium hydroxide conversion plant in Gwangyang, South Korea.
- **Posco** pledges \$4 billion cap ex for the “Salar de Hombre Muerto” (Dead Man’s Salt Lake) project straddling Salta and Cajamarca provinces in Argentina to start up near 25,000 t and increase to 100,000 t annually. For perspective, the lithium carbonate-equivalent size of the global market was near 305,000 t in 2020, and was nearer to 100,000 t perhaps 5 years earlier. Growth rates are near 50%.
- **Atlantic Lithium** in Ghana published a relatively high grade lithium resource at .205 mmt indicated resources at 1.29% lithium oxide and 9.6 mmt inferred resources at 1.19% lithium oxide. The deposit is shallow within 560 sq km with extensions along strike, depth or many satellite targets. Its “business plan” is to process 2 mmt per year for 0.3 mmt annually of 6% concentrate for 11.4 years.

FEBRUARY 2022

- **Glencore** established a battery cell and electronics recycling JV in the UK with Britishvolt in Northfleet, which will be anchored at Britishvolt’s Britannia Refined Metals operation. It is expected to start up in mid-2023 at a minimum of 10,000 t of lithium-ion batteries, electronics batteries and battery packs. One month earlier Glencore established a similar JV in Morocco with Managem, where this “template” may be repeated in the Americas, Asia or Europe.
- **Zijin Mining** will spend US \$380 mm to complete a 20,000 t lithium carbonate Tres Quebradas mine in Catamarca, Argentina after mid-2023 for full year 2024 output. In October 2021 it acquired Neo Lithium for C\$960 mm or UIS \$770.5 mm.
- **Controlled Thermal Resources** seeks to recover lithium near Salton Sea in California, where Freeport-McMoRan owned a geothermal power plant 3 or 4 decades ago. It seeks to extract lithium from deep pockets of hot geothermal brines. Its technology may involve 2,300 meter deep wells and some filtration or separation process to extract solids and separate lithium carbonate from other minerals in the brines. It is unclear whether the project will have environmental

and political support, where it lies in the desert on southeastern California near the borders with Mexico and Arizona.

JANUARY 2022

- **Battery Resources** announced on January 5th it will open a new recycling center in Covington, GA to recover lithium-ion batteries and engineered materials.
- **Glencore** and partner Managem will set up a facility in Guemssa suburb 37 km outside of Marrakech, Morocco to refine recycled cobalt, nickel and lithium battery metals. In view of Glencore's financial strength and technical expertise, Glencore could set up several similar facilities on each major continent. Glencore produces and has a large marketing focus already in virgin cobalt and nickel.
- **Rio Tinto's** Jadar lithium-borate project in Serbia suffered revocation of all of its licenses on January 20th, as Prime Minister Ana Brnabic caved into demands of several environmental groups. We estimate RIO invested over \$450 mm on the Jadar project, which had been a featured discovery at PDAC, was slated to supply 58,000 t lithium carbonate and 160,000 t of borates annually from 2027.
- **Lithium Power International** on January 18th published a definitive feasibility study for 15,200 t of lithium carbonate output annually for 20 years in Chile 51%-owned for \$626 mm cap ex with 39.6% IRR and \$1.4 billion after tax NPV at 8% discount rate.
- **Chemaf** DRC subsidiary of **Shalina Resources** obtained \$600 mm financing from trader Trafigura, which will market its output to 2027. Chemaf modernizes and industrializes prior artisanal cobalt mine sites into copper-cobalt mines. It mechanizes the Mutoshi cobalt-copper mine and SX-EW refinery in Kolwezi and expands the Etoile SX-EW plant in Lubumbashi. It targets output in 18 months after mid-2023. *We estimate a 10:1 copper-cobalt ratio, and estimate the projects target 50,000-100,000 t Cu and 5,000-15,000 t Co, but also displace prior artisanal Co outputs.*

DECEMBER 2021

- **Vulcan Energy** bought a 4.8 MW Rhine Valley, Germany geothermal plant for US \$33.6 mm, where it will extract lithium.
- **Leading Edge Metals** promotes the Norra Karr rare earth deposit outside of Granna, Sweden. Its PEA targets output of 5,341 tonnes annually of rare earth oxides, including 721 t of Nd + Pr, 248 Dy and 3 t Tb terbium. Neodymium and Prasneodymium are light, while Dysprosium and Terbium are heavy specific gravities.
- **Rio Tinto** will pay US \$825 mm to acquire the Rincon lithium brine project in Argentina. We estimate Rincon's output must be similar to the Jadar project in Serbia's 58,000 t planned lithium carbonate output to justify such a large price.
- **Rio Tinto** announced a "pause" to the Jadar lithium borates project slated to produce 58,000 t lithium carbonate and borate minerals by 2029. Farmers in the Jadar valley accounting for 1/5th of Serbian agricultural output, road blocks and a pending national referendum all pose obstacles. Some redesigns may be proposed.

NOVEMBER 2021

- **Tsingshan Holding Group** 35% and **Chengxin Lithium Group Co.** 65% will jointly build a 60,000 t annual lithium carbonate processing plant in Indonesia. It

targets importation of up to 450,000 t of lithium concentrates presumably from Australia, Chile, Argentina or other mining nations.

- **Tsingshan Holding Group** targets its own 24,000 t lithium carbonate output in Argentina. It also has a JV with Eramet and Jiangsu Lopal Tech Co Ltd to make the lithium iron phosphate battery materials in Indonesia such as Elon Musk discussed on Tesla's October earnings conference call for its Model 3.
- **Cornish Lithium** will spend US \$24 mm for a demonstration plant to test lithium processing recovery rates, drilling and a feasibility study for its Trelavour hard rock project in Cornwall. It also pursues the United Downs geothermal water test site and demonstration plant for direct extraction.
- **Firefinch Ltd** forecasts 2024 output of 436,000 t of spodumene lithium concentrate from its Goulamina project in Mali. It forecasts a 1 ½ year construction period beginning in 2022 second-quarter. China's Ganfeng Lithium invests \$130 mm to earn a 50% stake, and will refine the concentrates.
- Research to improve battery charge cycles advances, which may unlock a larger market segment for EVs. University of Twente researchers in Netherlands find a NiNb₂O₆ nickel niobate anode improves battery charging speed ten times.
<https://www.mining.com/new-material-improves-li-ion-battery-charging-speed-by-10-times/>

OCTOBER 2021

- **Rock Tech**, a Canadian firm, proposes a lithium hydroxide refining plant in Germany. It probably will source partly processed ores from Chile, Argentina, Nevada, Australia or elsewhere in a "hub-and-spokes" to refine for German automaker EVs.
- Ganfeng Lithium is advanced in China to refine lithium for Chinese EVs in a "hub-and-spoke" from imported ores also.

SEPTEMBER 2021

- **Tirupati** starts up a 9,000 metric t/yr flake graphite mine in Madagascar.
- **Lake Resources** partnered with a new 25% stake to Lilac Solutions of California to jointly develop the 25,500 t Kachi Lithium Brine project in Argentina.

AUGUST 2021

- **Ganfeng Lithium** plans a 35,000 t lithium carbonate mine for 2023 startup in Sonora, Mexico. It will buy out its publicly traded 50% partner to own 100%.
- Kwinana, Pinjarra and Wagerup historically have been Alcoa's 3 alumina refinery 10+ mmt locations on the Western Australian coast processing the favorable bauxites mined 90 minutes outside of Perth requiring relatively less caustic soda to refine than other global ores. In 2021 Kwinana redubs itself "Lithium Valley" where (1) Tianqi Lithium of China builds a lithium hydroxide plant, (2) Germany's BASF builds a pilot plant to run 2021 to 2025 in conjunction with the Australian government, (3) Albemarle of the U.S. and (4) BHP completes a nickel sulfate plant. *These processing plants encourage junior lithium or nickel explorers in Western Australia, where the explorers need to graduate to "mine" without building expensive refining abundantly available in Kwinana.*

JULY 2021

- **Rio Tinto's** board approved development of the \$2.4 billion Jadar lithium-borates project in Serbia, where output should start in 2026 and reach full development in

2029. Initial resources support 2.3 mmt lithium carbonate output over 40 years or 46,000 t annually. Full output after 2029 will be 58,000 t lithium carbonate, 160,000 t boric acid and 255,000 t sodium sulphate. The project is contingent in permit approval and support in a pending national referendum.
- **Intercontinental Energy** and **CWP Global** propose “Western Green Energy Hub” over 15,000 sq km in WA to produce 50 GW green hydrogen from wind or solar for A\$100 or US \$75 billion. For comparison, the largest coal generator in Australia is 2.9 GW.
 - **Jervois Mining Ltd** has board approval and will raise a US \$100 mm bond issue to fund its 100%-owned Idaho Cobalt project 40 km west of Salmon, ID. It owns 313 unpatented mining claims on U.S. Forest Service or federal BLM lands subject to EPA review, where it is permitted with an approved plan of operations. Jervois in 2019 acquired the partly built mine after the prior owner spent US \$120 mm to begin construction, which plans 1,200 tons/day underground mine and mill in late-2022 to sell separate cobalt and copper concentrates to target outputs of Co, Cu and Au. The project has 6.8 mmt at 0.42% Co, 0.64% Cu and 0.51 g/t Au. It targets about 5 mm lbs Co, 7 mm lbs Cu and 8,000 oz gold annually or 1% of world Co, 0.01% world Cu and 0.01% of world Au outputs.
 - **Ganfeng Lithium** on July 6th announced a 20,000 t annual Lithium plant for its Mariana project in Salta province of Argentina won environmental approval. It will be powered by its own 120 MW solar cells.
 - **Pallinghurst Group**, a European private equity firm, has invested \$0.5 of a planned \$1.0 billion total in battery metals in Quebec, including buyout of the bankrupt **Nemaska Lithium**, 15% of **Nouveau Monde** lithium and potentially into also bankrupt **North American Lithium**. The Quebec government promotes six lithium mining projects in Quebec as a sort of “AOC Green Deal” style ecology. *Over 5 years ago we declined to host Nemaska Lithium at our conferences out of skepticism about its operating and capital cost forecasts and the efficacy of its “acid bake” metallurgical process, which is an indicator of a very difficult molecule to “crack.”*
 - **BrineMine** is a joint project of the German Karlsruhe Institute of Technology applied geoscience department partnered with Chile’s Centro de Excelencia en Geotermia de Los Andes. A third BrineMine partner, the Fraunhofer Institute for Solar Energy Systems, will attempt to develop the commercial plant, which will make thermal electrical energy from the excess heat, purify water via reverse osmosis and attempt to make salable products from the recovered solids similar to a trial plant in Upper Rhine Graben. They aspire to both make clean drinking water and in the purification process extract commercially salable lithium, cesium and gold. Its focus will be thermal fields in the Atacama Desert. *It appears that each phase of the proposed system has been applied alone in other applications, where the unique advance is to combine the several together and apply them in combination to Chilean brines in the Atacama Desert.*

JUNE 2021

- **Retriev Technologies Inc.** and **HOBi Int’l** will partner to collect recycle large electric vehicle batteries in North America. Retriev is a lithium battery recycler based in Lancaster, OH. HOBi Int’l is a software systems, electronics and electronic recycler.

- **Stelco** and **Primobius**, a German battery recycler, plan a recycling venture with the goal of recycling 20,000 t annually of lithium-ion batteries.
- **Norsk Hydro** and **Northvolt** began a “Hydrovolt JV” in Fredrikstad, Norway to operate by the end of 2021 to recycle over 8,000 tonnes of electric auto batteries. Initial investment is 120 mm Norway Krona. It is conceivable the JV could later move into “end-of-life” auto recycling, where the vehicles also contain over 300 pounds of aluminum scrap important to Norsk Hydro as well as copper, steel, PGMs, lead batteries, etc. Separately, Northvolt and Volve are building a 50 GW battery factory in Europe to operate by 2026, and will need to source metals.
- **Lithium Americas** and partner **Ganfeng Lithium** approved a second stage expansion to the Cauchari-Olaroz lithium project in two solars in Jujuy, Argentina. Its initial capacity of 40,000 mtpd to expand to 60,000 mtpd lithium carbonate equivalent. It had a 40 year project life at 40,000 mtpd, which would fall to 27 years after expansion. It expects phase one first output in mid-2022 and phase two around 2025.
- **Ganfeng Lithium** will build a 50,000 t LiCarbonate plant in Fengcheng, Jiangxi province as it seeks to quintuple capacity to 600,000 t to be the global dominant Li producer. It will build two 25,000 t phases in modules or stages.
- **Ganfeng Lithium** will pay US \$130 mm to Firefinch for a 50% stake in the Goulamina hard-rock mine in Mali slated to produce 455,000 t of spodumene concentrates in its first phase. The Mali mine will feed the Fengcheng lithium carbonate plant presumably.
- **Ganfeng Lithium** in December 2020 negotiated to buy spodumene concentrates for 5 years from the Manono mine in DRC without taking equity in miner AVZ Minerals.
- **SQM** in Chile continues to target year-end 2022 output rates of 180,000 t lithium carbonate and 30,000 t of lithium hydroxide in Chile as well as pursuing a 50,000 t lithium hydroxide JV in Australia. SQM sold 66,000 t of lithium in 2020 at a steadily increasing quarterly rate of 9,000, 13,000, 18,000 and 26,000 t. It also sells iodine, potassium, SPN and industrial chemicals.
- **Sigma Lithium Resources** completed a second preliminary economic assessment for a second zone in Minas Gerais, Brazil at its Grota do Cirilo project to double target output to 66,000 t of lithium carbonate equivalent targeted for year-end 2023 after the phase one starts in late-2022. It has hard rock Li₂O grades at 1.55% in phase one and 1.43% in phase 2. It has operated a demonstration plant for two years and Mitsui has a take-or-pay contract for 100% of phase one output. It thinks it will be #6 largest global producer after **Albemarle**, **Ganfeng**, **SQM**, **Pilbara Minerals** and **Galaxy**. There are 9 past producing lithium mines on its 200 sq km land package offering more exploration potential.
- **Pilbara Minerals** will restart its Ngungaju lithium plant in Western Australia with price rebounds idled October 2019 after a plunge in lithium carbonate prices. It acquired the Altura lithium project in January 2021. It targets 180,000-200,000 dry metric tonnes within a year for mid-2022 output for US \$30 mm cap ex.
- **Ioneer** proposes a lithium-borate project to produce 24,000 tons of lithium carbonate and 192,000 tons of boric acid annually at the Rhyolite Ridge project near Tonopah, NV and the Albemarle silver Peak lithium mine. The US Fish and

- Wildlife Service proposes listing the “Tiehm’s Buckwheat Flower” as endangered species arguing that squirrels knowing roots and the Rhyolite Ridge mine may reduce the flower’s population by 70%.
- **Albemarle** targets process higher lithium recoveries from Chilean brines to 80%-85% from 50%-55%, where meeting even $\frac{1}{2}$ of the 30% target improvement would raise output by $\frac{1}{4}$ instead of $\frac{1}{2}$. It will spend \$200 mm on the yield improvement project to improve output 2 years from now. Separately, both Albemarle and SQM in Chile are under pressure to pump no more or even less brine and to reduce fresh water use. Thus, recovering more Li from the current salts pumped to surface from brines is politically and environmentally sound.
 - **Cornish Lithium** finished its United Downs geothermal water test site and demonstration plant to trial direct lithium extraction from geothermal water or from sea water. It will draw geothermal waters from the coast of Cornwall. It also studies hard rock lithium projects. *Great scientific enthusiasm exists for lithium recovery from sea brines rather than Chile, Argentina or Nevada brines.*
 - **Minmetals** in Qinghai province of China at Yiliping salt lake brine project employs a direct lithium extraction process to adsorb lithium separate from other impurities. It may apply such direct extraction either to sea water or salt brines. It is a 1,000 tonne pilot plant started in April. It previously used a membrane technology from Jiuwu Hi-Tech and solar evaporation, but the prior process needed 18-24 months.
 - Saudi Arabian researchers at King Abdullah University of Science and Technology published a paper in *Energy & Environmental Science* advocating a lithium lanthanum titanium oxide (LLTO) ceramic membrane and an outer chamber with a copper cathode coated in platinum and ruthenium passing over a platinum-ruthenium anode to recover lithium ions from sea water while blocking larger ions of other materials or minerals. Four more cycles follow. The process needs almost 200 kwh of electricity/kg Li. *We are skeptical of the complex process requiring 7 scarce minerals.*
 - **Nouveau Monde** advances the Matawinie graphite project located a mild 150 km north of Montreal, Quebec. Its 2018 feasibility study forecast 100,000 t of annual graphite concentrate output. It has strong political backing from the “AOC Wing” green energy zealots within the Quebec Liberal provincial party separate from the federal Liberal Party, where it seeks autonomy within the Canadian federal union.

MAY 2021 none

APRIL 2021

- **Rio Tinto** successfully refined battery grade lithium at its boron mine in Southern California, and will scale up to a 5,000 t or larger annual output.
- **Rio Tinto** made its first sale of a high performance AL-Scandium alloy made in North America to an additive manufacturer Amaero. The high purity scandium is refined at the Sorel-Tracy, Quebec “Fer et Titane” TiO₂ slag unit.
- **Rio Tinto** builds a plant to recover 20 t tellurium annually at its Utah CU refinery for \$2.9 mm to start up in the 4Q of 2021.
- **POSCO** of South Korea in 2018 acquired a salt lake in Argentina, where it has drilled to increase the lithium resources over sixfold to 13.5 from 2.2 mmt.

- **LKAB**, the historic operator of the “Kiruna” iron ore mine in northern Sweden that was key supplier a century ago to German war industries, beginning in 2022 will begin in 2022 to evaluate both the phosphorous and rare earth elements of its iron ores. It believes a 0.6% phosphorous content, if recovered, would supply 50% of Europe’s needs and improve the purity of LKAB’s iron ore products. It estimates rare earth element recoveries could supply 30% of Europe’s REE needs, and resemble the Baotou iron ore mines in China as major global REE supply.
- **Tsingshan Holding Group** will build a \$1.57 billion, 30 GW lithium-ion battery plant in Guangdong province in 2 phases to start up in 2023 and 2024.

MARCH 2021

- **Li-Cycle** in December 2020 started up a pair of plants in Rochester, NY to recycle 5,000 tonnes annually of lithium-ion batteries. It uses hydrometallurgy and claims to recycle 95% instead of 50% of the metals. *It envisions many “spoke” collection and shredding plants feeding the central Rochester hydrometallurgy separation/refining plant, which may be expanded in stages.*
- **Lithium Americas** partnered with **Gangfeng Lithium** in China, which has 90% offtake rights, targets mid-2022 Argentine output from its Couchari-Olaroz site to reach 40,000 t per year of lithium carbonate or 15%-20% of world needs.
- **Lithium Americas** also advances a 100%-owned Nevada project, Thacker Pass, which awaits a record of decision from the Bureau of Land Management.

FEBRUARY 2021

- **Vulcan Energy** advances the “Zero Carbon” lithium project in Ortenau, Germany, which targets a feasibility study in second-quarter of 2022 after an A\$120 mm equity financing. It seeks to produce lithium hydroxide, not lithium carbonate, and geothermal renewable energy. Its phases include brine extraction, geothermal power generation, lithium direct extraction and brine reinjection.
- **SQM and Wesfarmers** boards approved initial funding of the Mt. Holland lithium project and Kwinana refinery in Western Australia for 50,000 metric tonnes per year battery grade lithium hydroxide. They will move full force after permits expected in early 2022. The project will cost A\$1.9 billion for late-2024 output.

JANUARY 2021

- **Albemarle Corp.** will spend \$30-\$50 mm to double the lithium carbonate output in Silver Peak, Nevada, which supplies the Tesla battery factory in Nevada.
- **Lithium Americas** advances the 30,000-60,000 t lithium carbonate Thacker Pass project north of Winnemucca, Nevada on federal Bureau of Land Management ground. While the BLM is considered often a hostile landlord by gold, copper or other miners, Thacker Pass may get “kid glove” cooperation as a potential supplier to Tesla electric vehicles. The BLM released its EIS on December 4th.
- **Lithium Americas** also advances the 40,000 t lithium carbonate “Cauchari-Olaroz project in Argentina in JV with Gangfeng Lithium of China.
- **Rock Tech** plans a \$400 mm lithium refinery in Germany for 2023 output, which will import spodumene ores to supply the EU EV market from its own mine in Georgia Lake, Ontario in Canada.
- **Tesla** will operate its own spodumene conversion refinery to make lithium in Texas at Tesla’s battery plant.

- **Pensana** advances a \$125 mm rare earth processing and recovery facility in Yorkshire in the Saltend Chemicals Park.
- **First Cobalt** contracted 4,500 t of the 5,000 t annual feed for its cobalt hydroxide refinery in Temiskaming Shores, Ontario. Glencore will supply feed from Kamoto CU-CO in DRC and China Molybdenum from the former FCX Tenke Fungurume CU-CO mine also in DRC.

Universe Table 1: John Tumazos Very Independent Research, LLC Metals and Mining Coverage Universe											
			Price	Target	Mkt Cap	Shares	2020E	2021E	2021E	Gross Cash Flows	
	Steel	Rating	6/2/23	Price	(\$ mm)		EPS	EPS	P/E	CF/Share	P/CF
X	US Steel	O	21.95	48.9	5,597	255.0	(5.91)	14.88	1.5	3.43	6.4
NUE	Nucor	N	141.29	484.2	42,848	303.3	17.57	32.10	4.4	20.15	7.0
STLD	Steel Dynamics	N	97.71	125.0	18,369	188.0	2.61	15.67	6.2	4.94	19.8
ATI	Allegheny Technologies	N	38.78	20.0	5,926	152.8	(12.43)	-0.30	NM	1.05	36.9
WOR	Worthington Ind.(May FY)	O	59.93	96.3	3,062	51.1	\$2.07	13.42	4.5	\$5.25	11.4
	Gold Mining										20 P/CF
NEM	Newmont Mining	N	42.09	44.0	33,419	794.0	1.88	1.38	30.6	4.63	9.1
GOLD	Barrick Gold	N	17.31	14.4	30,775	1777.9	0.69	1.85	9.3	1.85	9.3
AGM	Agnico Eagle	O	51.95	37.8	12,627	243.1	2.10	2.22	23.4	4.98	10.4
AU	AngloGold	N	24.54	20.6	10,195	415.4	2.52	1.67	14.7	2.50	9.8
PAAS	Pan American Silver	O	15.52	0.0	3,264	210.3	0.85	0.46	33.6	1.74	8.9
	Royalty Companies				Mkt Cap						
RGLD	Royal Gold	O	123.58	79.3	8,119	65.7	3.11	2.84	43.5	5.55	22.3
FRV	Franco Nevada	O	123.49	96.2	23,278	188.5	2.09	2.02	61.2	3.85	32.1
WPM	Wheaton Precious Metals	O	45.36	38.3	20,465	451.2	1.13	1.67	27.1	1.40	32.3
SAND	Sandstorm Gold	O	5.42	7.0	1,270	234.3	0.07	0.14	38.8	0.34	15.7
OR	Osisko Gold Royalties	O	15.98	17.3	2,323	145.4	0.02	0.22	73.5	0.65	24.6
	Copper/Nickel/Diversified				Mkt CAP						20 P/CF
BHP	BHP Billiton ADR	O	58.72	51.6	148,855	2535.0	3.14	7.38	8.0	7.74	7.6
RIO	Rio Tinto ADR	O	63.17	51.3	102,576	1623.8	5.79	11.55	5.5	9.03	7.0
VALE	Vale	U	13.68	22.0	71,121	5198.9	1.93	2.17	6.3	3.49	3.9
GLCNF	Glencore	U	5.40	2.9	76,972	14254	0.09	0.11	51.1	0.64	8.4
NGLOV	Anglo American ADR	O	15.08	32.1	39,208	2600.0	1.67	2.44	6.2	5.57	2.7
NILSY	Norilsk Nickel ADR	N	24.17	23.9	36,933	1528.0	3.11	2.54	9.5	5.28	4.6
SCCO	Southern Copper	N	70.94	47.4	54,837	773.0	1.80	3.46	20.5	2.91	24.4
GMBXF	Grupo Mexico	O	4.63	7.3	36,045	7785.0	0.21	0.23	19.9	0.63	7.4
FCX	Freeport-McMoRan	O	37.19	31.5	53,963	1451.0	0.39	2.98	12.5	2.70	13.8
FSUMF	Fortescue Metals	O	13.08	23.4	40,392	3088.4	1.53	3.33	3.9	2.34	5.6
SOUHY	South32	O	13.15	14.8	13,345	1014.8	0.22	0.11	NM	0.38	34.9
TECK	Teck Resources Ltd	U	43.40	45.0	22,351	515.0	(1.62)	5.31	8.2	2.34	18.6
ANFCF	Antofagasta PLC	O	18.47	20.8	18,209	985.9	0.59	1.69	10.9	1.07	17.3
FCVLF	First Quantum	N	22.41	11.0	15,500	691.7	(0.23)	0.01	NM	1.50	14.9
CCJ	Cameco	O	30.08	11.6	11,905	395.8	(0.17)	(1.00)	NM	0.60	49.9
LUNMF	Lundin Mining	N	7.50	5.2	5,473	729.7	0.11	0.70	10.7	0.48	15.7
HBM	HudBay Minerals	O	4.77	8.7	1,246	261.3	(0.50)	1.10	4.3	0.73	6.5
	Aluminum										20 P/CF
AWQMY	Alumina Ltd	O	3.62	5.2	2,606	720.0	0.24	0.26	13.9	0.05	70.4
CENX	Century Aluminum	O	8.63	18.8	766	88.8	(1.38)	-1.85	NM	(0.00)	NM
HWM	Howmet Aerospace	N	45.13	11.2	19,826	439	0.59	3.61	12.5	1.40	32.2
AA	Alcoa	O	34.94	101.9	6,312	180.7	(0.91)	2.26	15.5	6.24	5.6

Sources: Company reports, AISI, Comex, LME and JTVIR, LLC estimates.

Universe Table 2: John Tumazos Very Independent Research, LLC Metals and Mining Universe Cont'd									
		Tang	Est. Tang			2020			
		Book	BV/share	Price/	2020	2020	EV/		
	Steel	Value	2020	Tang. BV	EV	EBITDA	EBITDA	Div.	Yield
X	US Steel	8,820	\$14.47	1.52	5,632	1,831	3.1	\$0.20	0.91%
NUE	Nucor	7,891	\$21.30	6.63	45,584	7,757	5.9	\$ 2.04	1.44%
STLD	Steel Dynamics	5,556	\$29.55	3.31	20,122	1,173	17.2	\$ 1.36	1.39%
ATI	Allegheny Technologies	245	\$1.61	24.14	5,933	978	6.1	\$ -	0.00%
WOR	Worthington Ind. (May fiscal)	268	\$5.25	11.41	3,860	347	11.1	\$0.96	1.60%
	Gold Mining		20 TBVPS					Div.	Yld
NEM	Newmont Mining	22,118	27.86	1.51	36,250	4,437	8.2	\$2.20	5.23%
GOLD	Barrick Gold	16,677	9.38	1.85	32,931	3,836	8.6	\$ 0.28	1.62%
AEM	Agnico Eagle	5,275	23.38	2.22	13,786	1,493	9.2	\$ 0.95	1.83%
AU	AngloGold	2,525	\$6.08	4.04	12,233	2,482	4.9	\$0.08	0.31%
PAAS	Pan American Silver	2,598	12.36	1.26	3,110	615	5.1	\$ 0.14	0.90%
RGLD	Royal Gold	2,292	34.88	3.54	7,953	379	21.0	\$ 1.50	1.21%
FRV	Franco Nevada	4,875	25.86	4.77	22,669	789	28.7	\$ 1.36	1.10%
WPM	Wheaton Precious Metals	3,107	6.89	6.59	20,467	671	30.5	\$ 0.60	1.32%
SAND	Sandstorm Gold	638	2.72	1.99	1,156	59	19.6	\$ 0.06	1.11%
OR	Osisko Gold Royalties	1,490	10.25	1.56	2,493	121	20.7	\$ 0.16	1.00%
	Copper/Nickel/Diversified		20 TBVPS					Div.	Yld
BHP	BHP Billiton ADR	54,018	18.73	3.14	167,012	20,533	8.1	\$ 2.40	4.09%
RIO	Rio Tinto ADR	43,378	\$26.71	2.36	113,443	20,338	5.6	\$ 2.35	3.72%
VALE	Vale	33,898	\$6.60	2.07	86,817	22,775	3.8	\$ 1.49	10.92%
GLNF	Glencore	36,838	\$ 2.63	2.05	106,471	11,770	9.0	\$ 0.37	6.86%
NGLO	Anglo American ADR	26,462	19.76	0.76	45,474	11,411	4.0	\$ 1.00	6.63%
NILSY	Norilsk Nickel ADR	6,199	\$ 4.06	5.96	41,219	8,066	5.1	\$ 2.17	8.96%
SCCO	Southern Copper	7,082	\$ 9.16	7.74	59,695	3,982	15.0	\$ 3.00	4.23%
GBMXF	Grupo Mexico	13,129	\$ 1.48	3.13	44,385	4,871	9.1	\$ 0.16	3.46%
FCX	Freeport-McMoRan	14,234	\$ 3.15	11.82	53,972	8,499	6.4	\$0.60	1.61%
FSUMF	Fortescue Metals	16,836	\$ 2.42	5.40	40,396	4,786	8.4	\$ 1.51	11.55%
SOUHY	South32	11,115	\$ 2.19	6.00	10,677	2,892	3.7	\$ 0.21	1.60%
TECK	Teck Resources Ltd	19,615	\$ 36.70	1.18	29,517	2,843	10.4	\$ 0.15	0.35%
ANTG	Antofagasta PLC	8,185	\$ 8.30	2.22	20,973	1,953	10.7	\$ 0.18	1.00%
QVLF	First Quantum	9,467	\$ 13.75	1.63	22,060	1,426	15.5	\$ 0.123	0.55%
CCJ	Cameco	4,928	\$ 12.40	2.43	11,798	425	27.8	\$ 0.09	0.30%
LUNMF	Lundin Mining	4,084	\$ 5.60	1.34	4,676	671	7.0	\$ 0.10	1.28%
HBM	HudBay Minerals	1,700	\$6.51	0.73	2,320	336	6.9	\$ 0.015	0.32%
	Aluminum		20 TBVPS					Div.	Yld
AWC	Alumina Ltd	1,598	\$2.22	1.63	2,678	174	15.4	\$ 0.22	6.19%
CENX	Century Aluminum	762	\$ 8.70	0.99	1,047	12	88.0	\$ -	0.00%
ARNC	Howmet Aerospace	(1,096)	-\$2.49	(18.09)	24,813	1,202	20.6	\$ 0.16	0.35%
AA	Alcoa	5,076	\$8.90	3.93	6,340	2,157	2.9	\$0.40	1.14%
Sources: Company reports, AISI, Comex, LME and JTVIR. LLC estimates.									

Universe Table 3: METALS UNDERLYING ASSUMPTIONS																	REVISED AND UPDATED March 18, 2023
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023E	2024E	2025E	2026E	2027E
U.S steel (mm Tons)	91.9	95.9	95.4	98.2	86.5	86.5	91.2	95.7	96.2	81.0	94.7	89.5	90.2	94.4	94.4	94.4	94.4
Gold Price (\$/oz)	1,585	1,662	1,406	1,267	1,160	1,249	1,258	1,289	1,392	1,771	1,796	1,808	1,900	1,925	1,950	1,975	2,000
Silver Price (\$/oz)	\$35.63	\$31.16	\$23.72	\$19.05	\$15.69	17.10	17.01	15.66	16.12	20.54	25.08	21.77	22.50	26.00	27.50	27.50	27.50
Copper Price (\$/lb)	\$4.00	\$3.63	\$3.34	\$3.12	\$2.51	\$2.20	\$2.81	\$2.92	\$2.72	\$2.79	\$4.23	\$3.99	\$4.00	\$4.00	\$4.00	\$4.00	\$4.00
Nickel Price (\$/lb)	\$10.42	\$7.93	\$6.83	\$7.66	\$5.37	\$4.35	\$4.71	\$5.95	\$6.33	\$6.23	\$8.38	\$11.87	\$12.00	\$9.00	\$9.00	\$9.00	\$9.00
Alum Ingot (\$/lb)	\$1.09	\$0.914	\$0.837	\$0.847	\$0.76	\$0.73	\$0.89	\$0.96	\$0.81	\$0.77	\$1.12	\$1.23	\$1.20	\$1.50	\$1.50	\$1.50	\$1.50
Lead (\$/lb)	\$1.09	\$0.99	\$0.97	\$0.95	\$0.81	\$0.85	\$1.05	\$1.02	\$0.91	\$0.83	\$1.00	\$0.98	\$1.00	\$1.35	\$1.35	\$1.35	\$1.35
Zinc (\$/lb)	\$0.99	\$0.88	\$0.87	\$0.98	\$0.88	\$0.95	\$1.31	\$1.32	\$1.15	\$1.03	\$1.36	\$1.58	\$1.50	\$1.20	\$1.20	\$1.20	\$1.20
Hot-Rolled Sheet(\$/net t)	\$ 764	\$ 674	\$ 638	\$ 676	\$ 521	\$ 568	\$ 649	\$ 788	\$ 671	\$ 600	\$ 1,315	\$ 1,008	\$ 850	\$ 1,000	\$ 1,000	\$ 1,000	\$ 1,000
Iron Ore benchmrk \$/t	\$168	\$129	\$135	\$97	\$56	\$53	\$71	\$67	\$93	\$109	\$160	\$122	\$120	\$110	\$110	\$85	\$85
Met Coal \$/t	\$ 257	\$ 193	\$ 149	\$ 115	\$ 95	\$ 100	\$ 150	\$ 175	\$ 175	\$ 120	\$ 209	\$ 325	\$ 300	\$ 225	\$ 225	\$ 225	\$ 225

Sources: Company reports, AISI, Comex, LME and JTVIR, LLC estimates.

Table 4: Summary Cash Flow Table for Forest Products Cverage (\$ r

Ticker	Stock Price	Mkt Cap	Mkt cap to Free CF 2023E	2021 EBITDA	2022 EBITDA	2023 EBITDA	2021 After Tax CF	2022 After Tax CF	2023 After Tax CF
	6/2/23		Forest Products and Paper Companies						
IP	30.38	11,909	6.7	2,732	2,888	3,321	3,271	2,355	2,822
LPX	60.85	4,424	(182.8)	1,971	1,592	390	1,538	1,174	261
WFG	70.88	7,584	8.5	4,924	2,240	1,386	3,943	1,856	1,193
PKG	128.08	12,104	17.0	1,659	1,877	1,507	1,469	1,661	1,453
WRK	28.86	7,484	4.1	3,034	3,475	3,108	2,765	2,802	2,816
GPX	25.00	7,738	10.6	896	1,459	1,649	826	1,308	1,281
WY	28.83	21,163	123.4	4,120	3,560	544	4,142	2,355	1,489
		Mkt cap to Free CF 2023E	Mkt cap to Free CF 2022E	2021 CAP EX	2022 CAP EX	2023 CAP EX	2021 Free CF	2022 Free CF	2023 Free CF
IP		6.7	9.5	549	1,100	1,050	2,722	1,255	1,772
LPX		(182.8)	5.8	254	414	350	1,284	760	(24)
WFG		8.5	5.2	375	400	300	3,568	1,456	893
PKG		17.0	14.5	605	824	600	864	837	713
WRK		4.1	3.8	816	850	1,000	1,950	1,952	1,816
GPX		10.6	10.2	802	549	549	24	759	732
WY		123.4	9.1	441	468	375	2,929	2,320	171

Sources: Company reports and John Tumazos Very Independent Research, LLC estimates

Universe Table 5: John Tumazos Very Ind. Research, LLC Fertilizer, Paper & Forest Products Universe																			
			Share Price	Target	Market Cap.	Shares Outstg.	EPS	EPS	EPS	EPS	EPS	P/E	2023E		Est. Tan BVPS	Price-to Tangible			
Ticker	Company	Rating	6/2/23	Price	(\$ mill.)	(mills)	2020	2021E	2022E	2023E	2024E	2023E	CFPS	P/CF	Dec-22	BVPS	Div.	Yield	
Forest Products and Paper Companies																			
IP	Int'l Paper	N	30.38	\$ 39	11,909	392.0	\$1.22	\$4.47	\$4.10	\$4.30	\$4.08	7.1	7.15	4.2	14.86	2.04	1.85	6.1%	
LPX	Louisiana-Pacific	N	60.85	\$ 60	4,424	72.7	4.42	\$14.09	\$13.87	\$2.37	\$3.34	25.7	4.38	13.9	17.89	3.40	\$0.96	1.6%	
WFG	West Fraser	N	70.88	\$ 123	7,584	107.0	8.59	27.03	11.13	5.04	4.14	14.1	11.15	6.4	49.17	1.44	1.20	1.7%	
PKG	Packaging Corp.	O	128.08	\$ 147	12,104	94.5	4.84	8.83	11.03	8.07	9.27	15.9	14.01	9.1	26.72	4.79	4.75	3.7%	
WRK	WestRock	O	28.86	\$ 55	7,484	259.3	(2.94)	3.13	3.61	3.55	3.77	8.1	9.55	3.0	12.25	2.36	1.10	3.8%	
GPX	Graphic Packaging	N	25.00	\$ 18	7,738	309.5	0.60	0.68	1.69	1.69	1.69	14.8	4.14	6.0	(1.76)	(14.17)	0.40	1.6%	
WY	Weyerhaeuser	N	28.83	\$ 31	21,163	734.1	1.07	3.47	2.53	(0.23)	0.44	-127.1	0.51	56.7	14.47	1.99	1.66	5.8%	
Source: Company Reports and John Tumazos Very Independent Research LLC Estimates																			

Source: Company Reports and John Tumazos Very Independent Research LLC Estimates

Universe Table 6: FOREST PRODUCTS UNDERLYING DYNAMICS													
Underlying Dynamics	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022E	2023E	
Uncoated Free Sheet (offset 50-lb rolls \$/t)	918	863	901	879	883	845	933	933	900	925	1,100	1,100	
NAm UFS Industry Volume (mm tons)	8.76	8.51	8.46	8.12	7.91	7.53	7.47	7.22	5.77	5.44	5.26	5.09	
Containerboard Price Realizaation (\$/t)	871	976	913	894	695	953	670	1,119	1,102	1,210	1,350	1,250	
NAm Containerboard Ind Volume (mm tons)	30.1	31.1	31.7	31.9	32.7	33.3	33.2	32.6	33.6	35.7	34.4	32.2	
Board Lumber (WY \$ per 000 sq ft)	347	423	426	379	389	442	482	389	534	759	550	475	
Plywood (WY \$ per 000 sq ft)	338	357	362	339	362	389	436	363	411	681	679	600	
Oriented-Strand Board (LPX prices \$/000 sq ft)	225	267	196	192	231	299	311	203	344	649	550	275	
Source: Company reports, Am. Forest and Paper Assn, Pulp & Paper Week, Random Lengths, JTVIR, LLC estimates													

CERTIFICATION OF OUR RESEARCH OPINIONS

I, John Tumazos, certify that the opinions written in all research reports are my own. I believe what we write, and from time to time I may buy or sell the shares we recommend after a 48 hour delay after publishing our reports following the advice we give. Further, I personally proofread and “click the pdf button” on virtually every report we publish except sometimes when I am abroad.

Our team or employees is encouraged to disagree with me at any time. We have active and vigorous internal debates concerning appropriate discount rates or long-term terminal growth rates to use in net present value valuations or other analytical issues. My team realizes that customers want to pay for my 30+ years of experience, but I encourage them to disagree, correct or provoke debate to improve our work.

DEFINITION OF A RESEARCH OPINION

We have target prices, investment ratings, earnings estimates and financial models for 47 companies upon which we maintain regular research coverage.

The legal or regulatory definition of research, however, is more broad. Regulators consider any written or editorial commentary about a stock or publicly traded company to be “research.” However, a “recommendation” or “opinion” is not rendered unless there is a price target and specific buy or sell recommendation.

From time-to-time we visit very large, important global companies outside our research coverage. Our objective may be to be well informed about industry events, predict future mine output or “supply” in a particular market or to begin to learn about a complex company to begin future full research. We may need to learn and become familiar to provide inputs to our financial models. In May 2008 we published a partial report on Xstrata after visiting two of its mines in South America. In November 2008 we published a partial report summarizing our visits to the London headquarters of Xstrata and Anglo-American outside our coverage as well as Rio Tinto and Antofagasta PLC within our full coverage. In August 2009 we published two research reports on Severstal after visiting its Columbus, MS newest steel plant a second time. These “partial” reports contained no price target, investment rating, earnings estimates or financial models.

Instead, they provided detailed descriptions of the important locations we visited or meetings in headquarters.

We provide research about commodities markets in general, “seminar highlights” on up to another 75 or more companies we host annually at our conferences outside our regular full research coverage and “partial reports.” We have no price target, written investment opinion, earnings estimates or financial models (production, incomes statement, cash flow or balance sheet simulations) of such companies outside our coverage that speak at our March or November conferences. Any viewpoint we have without complete financial models or careful financial analysis is “winging it.”

Our intent in writing Seminar Highlights is to provide a one page written summary of each seminar participant company’s presentation. We provide live open, public, unrestricted webcasts of each such corporate presentation at our conferences as a courtesy to each participating company, and archive each webcast under the “conferences” tab of www.veryindependentresearch.com.

Our clients should not automatically consider our invitation of a company to speak at our future conferences as a “Buy Recommendation” or complete endorsement. We may not have visited the mines or assets of some of these companies. Occasionally we invite a company to speak to learn more about them as a stage in our learning process.

ORGANIZATION OF JTVIR

John Tumazos Very Independent Research, LLC (JTVIR) organized as a registered investment advisor in the State of New Jersey in 2007 moved to Florida in 2022. We are regulated by the FL Bureau of Securities as of June 2022 after 15 years of operations in the State of New Jersey. We published up to 20 research reports each month covering about 40 to 50 stocks in the metals commodities markets, forest products, aluminum, steel, gold, copper and other mining sectors. We travel abroad or domestically visiting companies, although virtual meetings have become more common after pandemic. We host Conferences each year in which companies make presentations, which are archived for roughly one year at www.veryindependentresearch.com under the “conferences” tab.

Currently we have over 20 paid clients in the U.S., Canada, and U.K, but none in FL. Three of our clients have engaged us to write “custom studies” on pre-production mining stocks without any U.S. or global research coverage, including Skye Resources (an 11 bil lb nickel resource in Guatemala), Mercator Minerals (a copper-moly restart in Arizona) and JSW Steel’s 70%-owned Minera Santa Fe (48 sq km undrilled magnetic anomaly and associated iron ore properties in 3rd Region of Chile).

JTVIR DISCLOSURES

“John Tumazos Very Independent Research, LLC” (JTVIR) is a Florida Corporation as of 2022 after prior formation as a Delaware Corporation July 6, 2007 with registration effective on August 27, 2007 as an investment advisor in the state of New Jersey owing to our place of business in New Jersey, where we moved to Florida in July 2022.

JTVIR is not a broker-dealer, and conducts no trades. Its primary business is to provide “unbundled” metals, paper and fertilizer industry securities and market research to institutions or corporations in a zero commission, electronic execution, electronic dissemination, unbundled format for a specified annual fee structure.

Our investment rating system for securities recommendations is Overweight, Neutral Weight or Underweight. Overweight or Underweight recommendations are estimated to vary from the relative performance of the S&P 500 by more than 10% annually, and the intended time horizon is up to 24 months. Our securities research is intended for institutional investors that might buy up to 10% of a given company, and as such focuses more towards longer-term dynamics impacting the net present value of future cash flows rather than “day trading” sorts of near-term issues.

Except for WestRock, Packaging Corp., South32, Glencore, Grupo Mexico, Worthington Industries, Century Aluminum, Alcoa, Alumina Limited, Norsk Hydro, Rio Tinto, BHP, Anglo American, Norilsk Nickel, Polymetal Int’l, Solitario Zinc, Agnico-Eagle Mines, Pan American Silver, Paramount Gold Nevada, Fortescue Metals, Akora Resources Ltd, Alamos Gold, Victoria Gold, Fresnillo Silver, SilverCrest Metals, Pan American Silver Escobal mine contingent value right, Wesdome Mines, Novo Resources, McEwen Mining, Cerrado Gold, Sandstorm Gold Royalties, EMX Royalties, Osisko Gold Royalties, Osisko Mining, Rupert Resources, Voyager Metals, Texas Minerals Resources Corp., North Peak Resources, Galway Gold, and Galway Metals, neither JTVIR, its members or its employees own or have a financial interest in any securities discussed in this report or any reports we have published recently. Our policy is full disclosure.

As of mid-2018, my son Charles Tumazos took full control of accounts in his name after age 30. He controls his accounts and makes his own decisions. Going forward, we will disclose John Tumazos’ personal holdings and exclude “family accounts.” Our positions will be a little smaller.

Our policy permits personal trading in the metals or paper industries. Our policy is that any personal trading must be consistent with our recommendation, made two business days or more AFTER a recommendation or change in recommendation and held for a minimum of 30 days or one month. We believe it is virtuous for a securities analyst to “put his or her money where his mouth is” to invest consistent with the recommendation to clients after such recommendation has been made, and we disagree with some restrictions made upon broker-dealer employees after 2000 era scandals.

However, our policy permits up to one directorship and up to five consulting projects, advisory assignments or financial advice to corporations. Our policy is full disclosure of any advisory relationship or conflict going back three years.

We have enjoyed over 25 corporate advisory relationships since our formation in 2007 often in “pre-revenue” earlier stage resources, which are organized in a separate LLC “John Tumazos Very Independent Opinions, LLC.” In 2021 current relationships include North Peak Resources, Granada Gold Mines and Akora Resources Ltd. Past relationships

include capital introductions for Galway Metals, Appia Energy, Akora Resources and Texas Minerals Resource Corp. Past Relationships include “fairness opinion” valuations for Augen Gold, Paramount Gold and Silver, Tara Gold, Tara Resources, Belvedere Resources and Lemhi Gold Trust. Past relationships include strategic advisories to Galway Resources, Granada Gold and Platinum Group Metals. Past relationships include formal written critiques of NI 43-101 technical studies for McEwen Mining and Sprott Resource Holdings. Past relationships include asset sales for Romios Gold, Morenci 8 LLC, Minex’ Black Horse property in Ely, NV and a Mexican silver deposit.

Numerous prior investment banking relationships existed prior to three years history to the pre-1997 time frame under the employment of Donaldson, Lufkin and Jenrette or Oppenheimer & Co., Inc. Some of these we can recollect included 14 different gold mine valuations or sales for Barrick Gold, LAC Minerals (later acquired by Barrick), Addington Resources (gold assets in Montana acquired by Canyon Resources), Westworld Industries (Bolivian assets acquired by Battle Mountain Gold later acquired by Newmont Mining), Coeur d’Alene Mines, Crown Resources (acquired by Kinross Gold), Freeport-McMoRan Gold (acquired by Minorco later AngloGold later Queenstake Resources), FMC Gold (later renamed Meridian Gold) and others. Sole managed initial public offerings included Reliance Steel & Aluminum and Huntco. Lead-managed initial public offerings included American Steel & Wire (later acquired by Birmingham Steel) and lead-managed underwritings included Quanex. Co-managed underwritings included the IPO of Century Aluminum and Grupo Imsa and offerings for AK Steel, Kaiser Aluminum, Agnico-Eagle Mines, Cameco and others. Asset sales or purchase advisories, fairness opinion or trusteeships were done for Thypin Steel (sold to Ryerson Tull), Cyclops Corp. (sold to Armco later sold to AK Steel), Allegheny Corp., Bethlehem Steel, the U.S. Dept. of Justice pursuant to the June 1984 merger of LTV and Republic Steel to sell the Gadsden, AL integrated flat-rolled mill, Cobre Copper, and others. Some examples we can recall of incomplete transactions for which a prospectus was either drafted or partly drafted indicating much work included stock underwritings not completed for Wheeling-Pittsburgh Steel, Steel Dynamics, Atlas Corp., Webco, Sharon Steel, IPSCO, Co-Steel Inc., and others.

ANALYST UNIVERSE COVERAGE:

John C. Tumazos, CFA as of June 2007: Rio Tinto, Louisiana-Pacific, Nucor Corp., Newmont Mining, U.S. Steel, International Paper, BHP Billiton, MeadWestvaco Corp., Antofagasta PLC, Allegheny Technologies, Alcoa Inc., Inco Limited, Bowater, Temple-Inland, Barrick Gold, Abitibi-Consolidated, Weyerhaeuser Co., Alcan Inc., Smurfit-Stone Container, Plum Creek Timber, Worthington Industries, Goldcorp Inc., AngloGold Ashanti, Freeport-McMoRan Copper & Gold, and FNX Mining. Dynatec, Alcan and Bowater are companies not continued in the research coverage of JTVIR, LLC that was previously included in the prior June 6, 2007 Prudential Equities Group universe owing to takeovers. Smurfit-Stone Container and AbitibiBowater were dropped from JTVIR research coverage after they entered bankruptcy. Skye Resources, FNX Mining, QuadraFNX Mining, Thompson Creek Metals, Duluth Metals, Xstrata, MeadWestvaco, Smurfit-Stone Container (new), Goldcorp, Detour Gold, Norbord were dropped after full coverage initiation due to takeover. We later dropped Greystar Resources/ Eco-Oro, General Moly and PolyMet Mining from coverage as their project delays extended beyond one decade.

Subsequently, since September 2007 JTVIR, LLC has initiated regular coverage of new companies not previously covered in the former universe at the former Prudential Equities Group. These new companies include CF Industries, Mosaic, Franco-Nevada, Silver Wheaton, Royal Gold, Osisko Gold Royalties, Sandstorm Gold, Detour Gold, South32, Teck, Agnico-Eagle Mines, Mercator Minerals, Skye Resources, General Moly, Inc., Thompson Creek Metals, Duluth Metals, Polymet Mining, Greystar Resources, Vale, GlencoreXstrata, Glencore, Xstrata, Anglo American, Packaging Corp. of America, Norbord/West Fraster, Rock Tenn/WestRock, HudBay Minerals, Alumina Ltd., Fortescue Metals, and Century Aluminum.

In accordance with applicable rules and regulations, we note above parenthetically that our stock ratings of “Overweight,” “Neutral Weight,” and “Underweight” most closely correspond with the more traditional ratings of “Buy,” “Hold,” and “Sell,” respectively; however, please note that their meanings are not the same. (See the definitions above.) We believe that an investor’s decision to buy or sell a security should always take into account, among other things, that the investor’s particular investment objectives and experience, risk tolerance, and financial circumstances. Rather than being based on an expected deviation from a given benchmark (as buy, hold and sell recommendations often are), our stock ratings are determined on a relative basis (see the foregoing definitions).

There is no intention to “balance” the number of Overweight or Underweight ratings, as instances of broad over- or under-performance among basic industrials may occur. JTVIR makes each investment judgment in a “bottoms up” manner based on the assets of each individual company.

Price Target – Methods/Risks

The methods used to determine the price target generally are based on future earning estimates, product performance expectations, cash flow methodology, historical and/or relative valuation multiples. The risks associated with achieving the price target generally include customer spending, industry competition and overall market conditions.

Additional risk factors as they pertain to the analyst's specific investment thesis can be found within the report.

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Information contained herein is based on data obtained from recognized statistical services, issuer reports or communications, or other sources, believed to be reliable. Any statements nonfactual in nature constitute only current opinions, which are subject to change.

There are risks inherent in international investments, which may make such investments unsuitable for certain clients. These include, for example, economic, political, currency exchange rate fluctuations, and limited availability of information on international securities. John Tumazos Very Independent Research, LLC, and its affiliates, make no representation that the companies which issue securities that are the subject of their research reports are in compliance with certain informational reporting requirements imposed by the Securities Exchange Act of 1934.

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Additional information on the securities discussed herein is available upon request. The applicable disclosures can be obtained by writing to: John Tumazos Very Independent Research, LLC, 11 Yellow Brook Road, Holmdel, NJ 07733 Attn: John C. Tumazos.

BOARD OF TRER AUGUST 6, 2012 TO MAY 27, 2013

On August 6, 2012 we joined the board of Texas Rare Earth Resources, and were elected Non-Executive Chairman. We made an early stage investment in the company after it obtained its core property in the fourth-quarter of 2010, and we and other activist shareholders believed there was room for improvement in its business plan and performance in 2012. We did not expect our participation in TRER to be indefinite, and believed that it will seek a larger mining company to help it complete its projects.

On May 27, 2013 we resigned from the Board of Texas Rare Earth Resources. We were pleased that metallurgical research into sulphuric acid heap leach processes made advances, which determined an alternative process requiring 10% to 20% of the cap ex proposed in the prior June 15, 2012 NI 43-101 study. The 2010 identification and possession of the property and the 2013 metallurgical advances added value, and we thought a larger organization would better develop the production plant.

We declined all other invitation to join Boards of Directors. We do not want distractions or other activities to weaken JTVIR, LLC. Further, we have a "team psychology" and a large commitment to one another within JTVIR, LLC.

JTVIO

John Tumazos Very Independent Opinions, LLC (JTVIO) is a separate company providing various services "other than" investment research sold to institutions in JTVIR.

Counsel advised any other activities be organized separately. Such other activities have involved < 5% of our time. Since 2008 we have done such advisories for 18 companies, or 1 or 2 assignments per year typically.

In general, we may provide investment banking or advisory services mostly to sub-\$100 mm mining companies that have defined a “deposit,” but need more capital after a discovery for infill drilling, bulk metallurgical testing, definitive feasibility study or the capital outlays to build a mine. JTVIO envisions merger advisory, “second opinion” critiques of investment banking advice, strategic consulting, valuation opinions, fairness opinions, mine technical services such as “Third Party Reviews” of technical studies or other corporate services. The “research coverage” of JTVIR largely involves very large companies with completed steel, aluminum, forest products or mine plants with market capitalizations usually between \$1 and \$250 billion. Historic companies often over one century old, such as Alcoa or U.S. Steel or BHP Billiton, will use top ten commercial or investment banks for advisory services and we make no attempt to be engaged by them owing to their long historic relationships.

We prefer to advise companies without revenues, which large investment banks like Goldman Sachs, JP Morgan, Morgan Stanley or BMO often avoid. Such mining companies without revenues are not as competitively over-banked, and many of the geologists are quite gifted and have extremely promising projects.

We undertook some platinum market studies for Platinum Group Metals in the past year.

We critiqued the NI 43-101 Preliminary Economic Assessment or Feasibility Study for publicly traded Toronto producing companies for copper projects in Argentina and Chile.

We have accepted compensation from Texas Rare Earth Resources, Akora Resources, Galway Metals and Appia Energy, a private concern, related to introducing investors to them.

In August 2011 we advised the Board of Directors of Augen Gold that a hostile tender offer from Trelawney Mining. On October 9, 2010 we were engaged by Tara Gold Resources to evaluate the fairness of their September 13, 2010 proposed merger to amalgamate with Tara Minerals, which it terminated on March 7, 2011. We delivered a “structure opinion” to Tara Gold Resources and Tara Minerals on May 20, 2011 that the cancellation of the announced September 13, 2011 merger was “fair.” On June 24, 2010 we delivered a Fairness Opinion to the board of directors of Paramount Gold and Silver for compensation in their acquisition of X-Cal Resources, Ltd concerning the Sleeper gold mine near Winnemucca, NV formerly operated in 1986-1996 by Amax Gold and having past output of 1.66 mm oz gold and 2.3 mm oz silver plus 26,000 oz of placer gold almost one century ago. We provided a valuation opinion in 2016 for Belvedere Gold for a gold exploration property in Finland. We provided a valuation opinion for an SEC filing for a trust for a gold deposit in Lemhi County, Idaho in September 2017. We attempted to market and valued a 350,000 oz heap leach gold deposit in Ely County, NV in 2017-18.

In January 2020 we advised a partnership of landowners as a 1/7th co-owner in the sale of 82 acres adjoining the northwest of the FCX Morenci open pit, called “American Mountain,” to Freeport-McMoRan Inc. In 2017-18 we advised some partners on the royalty of the San Juan open pit of FCX’s Safford mine, who failed to pay us.

On October 6, 2010 we were engaged by Dorado Ocean Resources Limited, a privately held company. That assignment has concluded without success or compensation.

Since 2016 we have provided strategic advice to Granada Gold Mine.

On June 3, 2008 Galway Resources engaged JTVIO to commercialize its Victorio, New Mexico molybdenum-tungsten deposit containing over 200 mm pounds of each mineral in situ, which is JTVIO’s first activity (see www.galwayresources.com June 3, 2008 press release). We have received compensation from Galway Resources.

These past engagements pose no “conflict of interest” with JTVIR research coverage as long as JTVIR does not cover or write on Paramount Gold and Silver, Galway Resources, or other sub-\$250 mm market cap emerging companies. However, subsequently Galway Resources has documented gold occurrences on Galway grounds and begun drilling. After our November 6-12, 2009 trip to the California gold district of Colombia, we published research reports on Greystar Resources and NOT Galway Resources to avoid conflicted research. We omitted Galway Resources from our “Conference Highlights” report even though it spoke at our November 19, 2009 conference in a similar vein to avoid conflicted research.

JTACR

John Tumazos Advisory and Compensated Research, LLC (JTACR) is a separate investment advisor registered with the State of New Jersey Bureau of Securities on June 27, 2011 as CRD # 157,606. **Under no circumstances will JTACR be commissioned by a mining or other publicly traded company simply to write a “paid” research report.** Its purpose is to include research reports after separate compensation has been received for an advisory service such as a fairness opinion, mergers & acquisitions advice, introductions of investors in a capital raising or other advisory services. Regulators presume that any “compensation” or potential compensation biases research reports, however small, and outside counsel advises us that we should not write about a company as “John Tumazos Very Independent Research, LLC” if compensated or seeking compensation.

We have created a separate web site, www.advisoryandcompensatedresearch.com to support JTACR. It is separate from our normal research investment advisor site, www.veryindependentresearch.com. Since the second half of 2011 JTACR has published research reports on Texas Rare Earth Resources, Texas Mineral Resource Corp., Akora Resources Ltd., Paramount Gold and Silver, Paramount Gold Nevada, Galway Resources, Galway Gold, Galway Metals and Platinum Group Metals. These represent < 10% of our company research and < 5% of our written research report output.

MONEY MANAGEMENT ACTIVITIES

We manage my own money and several client accounts. Our trades conform to our published research and follow publication by a minimum of two business days with a 30 day minimum holding period for personal trades. Client recommendations have first priority.

In November 2011 we accepted our first customer money management account, and we are beginning to set up an account and legal agreement to manage money for him. We are in the process of completing such paperwork.

Money Management for clients could be another line of business. “Mine Development Fund” is a “current” project to establish a small fund to invest in post-discovery, large resource companies (over \$2 billion in situ mineral value already defined) requiring financing to “build the mine” and grow. The target market cap of the companies in which it would invest would be \$0.1 to \$10 billion. Our detailed studies of emerging mines may prove synergistic across several applications. We have also considered creating sector ETFs, but determined there is more value-added in fund management.

Our published over 3,000 research reports to Since July 7, 2007 has concentrated on the metals commodities themselves, steel, aluminum, forest products and larger capitalization mines like Rio Tinto, BHP, Freeport-McMoRan Copper, Barrick Gold, etc. Only 7%-10% of our written research involves the “sub-\$2 billion mine” size range that would be the focus of either JTVIO or Mine Development Fund. Thus, compliance issues or conflicts of interest would occur in a smaller subset of JTVIR coverage as JTVIR coverage involves larger caps, “established processing companies” or commodities. JTVIO or the buy-side investing may focus on much smaller companies

POTENTIAL MINE SERVICES ACTIVITIES

We delivered a written critique for two NI 43-101 compliant studies of copper deposits in Argentina and Chile for publicly traded companies based in Toronto. One was a second preliminary economic assessment for a deposit with approximately 30 billion pounds of copper and 5 mm oz of gold. The other was a definitive feasibility study to expand a small open pit and underground copper mine with an established production history.

As a substantial user of mine feasibility study reports or other technical reports prepared at early stages after first discovery, sometimes we are very dissatisfied. We may from time-to-time provide “Third Party Review,” critique such mine scoping study or prefeasibility study reports. We do not seek to “second guess” scientific issues of mine engineering or metallurgy. However, we may differ with the mathematics of reserve determination, capital cost estimates, “simultaneity” of price and cost assumptions, various business planning issues, the opportunity to “phase” or subcontract to reduce initial capital costs or other financial issues. The “custom studies” we have provided to several buy-side JTVIR customers may resemble “Mine Services” future products presented as “Third Party Review” of mine technical studies.

CONFERENCES

Since 2008 we have hosted investor conferences as “John Tumazos Very Independent Research, LLC” similar to our having hosted investor conferences or individual meetings since 1982 under the auspices of Oppenheimer & Co., Inc, DLJ, Bernstein or Prudential Financial in earlier employment. We have hosted a number of very large companies, including Vale, Teck, Barrick Gold, Agnico Eagle Mines, Yamana Gold, Pan American Silver, HudBay Minerals, Century Aluminum or others. We have found that some of our friends at large companies did not accept our invitations since 2008, however, such as BHP, Rio Tinto, Alcoa, U.S. Steel, Freeport-McMoRan Inc. or others.

Beginning in 2008 we began to invite companies with a “resource deposit” scrutinizing their NI 43-101 or JORC compliant resource statements, preliminary economic assessments (PEA), prefeasibility study or feasibility study documentation. Our two principal criteria are (1) a documented mineral resource > US \$3 billion and (2) a “business plan” or coherent strategy to make money. However, we make exceptions for (1) the next project or spinoff of a successful geology group after they have sold a discovery for an epic large sum, (2) a project adjoining a fertile known property, (3) a restart of a historic mineral district of the 19th or 20th century, or (4) occasionally a photograph or other evidence of a bulk mineral occurrence. We reject geology theories or early stage ideas in most cases.

We manage our conferences to “maximize information content” or learnings focusing on mineral properties that interest us. We manage our conferences for the (1) benefit of the investors that pay us for advice, (2) for the benefit of the speaking companies many of whom are our friends, (3) to learn and invest ourselves and (4) to advertise our small enterprise to win future research, money management or corporate advisory customers. We screen the companies we host, but our hosting a meeting or virtual meeting for a company **does not constitute a buy or sell recommendation**. Very often we may find a company or project “interesting,” and are just learning more about it or getting to know it as a stage in our learning process. We are blessed that many famous geologists from around the world speak at our programs or listen to the webcasts we host.

Since 2008 we operated our conferences on a “Dutch Treat” basis, asking the companies to pay their portion of the catering, hall rental, webcasting and various other hard expenses plus a month of my payroll or overtime bonus to our team. Since we moved to the suburban Greek Orthodox church hall in Holmdel, NJ or in 2020-21 in a virtual meeting format our costs fell and the size and popularity of our programs has increased. While it was not our strategy to run our conferences as a primary business, they have grown and become profitable. While it is not our intent to be an “investor relations” company, our meetings have become immensely popular both with the companies we host and the investor audience. It appears both the companies we host and the audiences appreciate our detailed questions about resource estimation, gold mine geostatistics, geology, costs, feasibility study details, mine engineering, end markets or other opportunities.

Since 2008 we have hosted 112 companies bought out for U.S. \$103 billion combined at our conferences. These included 68 gold deposits or miners, 12 silver, PGM or royalty precious metals companies, 5 hard rock energy and 27 companies in other minerals or formats such as copper, zinc, nickel, moly, a phosphate deposit or a national steel distributor. The majority of these have been in Canada, the U.S. or Mexico, but there have been a few across Latin America, Africa, or elsewhere around the world. Ontario, Quebec, British Columbia, Alberta, and Nevada are notable areas where we have found many successful investments. Our screening strategy of a focus large undeveloped deposits has been useful to identify the companies large mines buy out if they need new deposits to grow or replace depletion. Our focus on geology and willingness to ignore low market capitalization, ignore the absence of revenues and willingness to ignore \$0.2 to \$5+ billion initial capital needs has been effective. The future acquirers fund the constructions.

Our policy has been to host open public webcasts for many reasons including to learn from the presentations, to serve our investor clients, the benefit of the speaking companies, to help make our small business better known or to comply with SEC Regulation FD for fair disclosure. We seek to grow all of our efforts or businesses by “word of mouth” or good reputation. We have learned that companies that resist an open public webcast may be “toxic,” or suffer some labor relations, environmental or other defect. Recent rebounds in metals prices or stocks have made our webcast followings larger growing from about 1,000 in 2018 from 40 nations to 1,700 in 2019 from 49 nations to 2,600 in 2020 from 63 nations where we exclude employees of the participating companies or in 2020 we excluded 1,030 listeners to Northern Dynasty some of whom were environmental opponents or job seekers rather than investors. In 2021 our roster of speakers grew to 77 companies from 46 in 2020, although the listeners fell with gold prices towards 1,800 from 59 nations.

In 2021 we organized our virtual conferences into February, April, June, August, October and December two day sessions with up to eight companies per day at 75 minute intervals, which is a “capacity” for up to 96 companies where we expect we will schedule perhaps over 80 of the time slots. Some companies have asked us to host multiple meetings for them in 2021, but we want to host DIFFERENT companies to learn about more investment ideas. But this illustrates a larger “pent up interest” in such activities.

For 2021 we host our video conferences for free for companies > US \$3 billion market value, which we regard and execute “just like a research interview.” We should embrace such opportunities as research analysts to learn and be better investors. For smaller companies we charge US \$2,700 for repeat companies and \$3,500 for first-time companies as we spend much time learning about them to vet them. We deliberately charge < ½ as much as investor relations firms that often charge US \$6,000 for a meeting, an annual contract or ask for warrants or options too. We want to pick good companies and for the good companies to find us or call us preferentially.

RADIO SHOWS AND OTHER MEDIA

We have declined invitations to host or participate in regular radio shows, as we have too many responsibilities to cover 42 large capitalization stocks, keep updated financial models with at least 5 spreadsheets for each large cap company, keep up with supply-demand models in important commodities, host up to 77 mostly smaller companies at our conferences, manage portfolios or undertake corporate advisory projects.

Since 2017 representatives of WABC radio approached us to help introduce companies to them to present in radio shows. They attended our conferences to identify subject matter for John Batchelor or Larry Kudlow's business shows. They offered me appearances or advertising time, but we had reservations about "mass market inquiries" from individual unable to buy our services. WABC never paid us or proposed to pay us. Our impression is that Bloomberg, WABC or other media companies have a large access to unpaid speakers seeking exposure.

In 2021 VoiceAmerica Business channel approached us to have radio shows. Our friend, Jay Taylor, writes a newsletter and it turns out since 2009 he has had a radio show on VoiceAmerica Business for whom he gave a good reference. We liked this format, but simply are spread too thin to undertake such a task presently.