



Fables of the Reconstruction:
Flawed Road to a Carbon-Neutral Economy
 Yukon Geoscience Forum & Trade Show
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J. MAZUMDAR - EDITOR/ANALYST

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Fables of the Reconstruction:
 Flawed Road to a Carbon-Neutral Economy

- **What is a critical mineral?**
- Demand for critical minerals
- Sources of critical minerals
- Exploration, capex and financing trends
- Yukon example – Casino copper-gold porphyry
- ESG risk
- Processing capacity
- Summary & Conclusions

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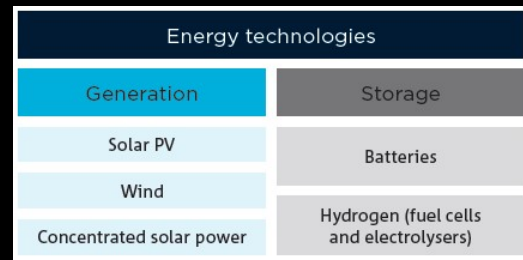
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What is a critical mineral?

- Achieving the goals of the **Paris Climate Agreement** to limit the temperature rise related to the increase in carbon emissions requires a dramatic shift of energy sources and a reduction in the number of ICEs on the road.
- A critical mineral is:
 - required for this transition to a low-carbon economy
 - supply chain security
 - Potential to be a sustainable source of supply to partners and allies



Source: Critical Energy Minerals Roadmap, CSIRO

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Different interpretations of what is critical

- The **US Energy Act of 2020** directed the USGS to update the list of critical minerals
- Currently 50 elements and commodities are critical, interestingly, **copper was just added while uranium is still not included**
- The Australian government has declared 26 elements and commodities to be critical (copper is not included)
- European and Canadian regulators have declared 22 to 31 minerals critical including copper

Periodic table of the elements

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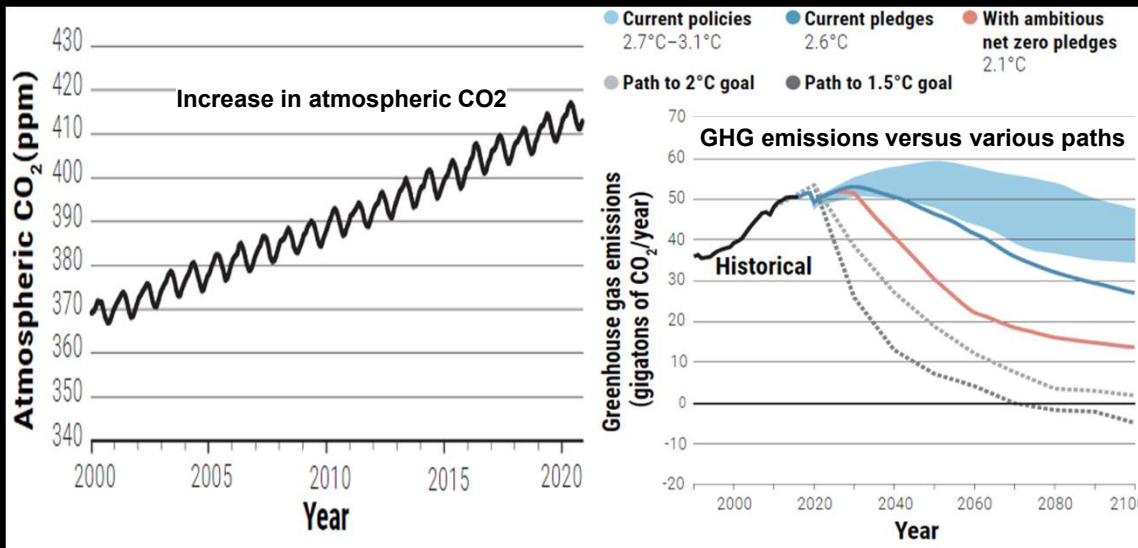
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Path to 1.5 degrees is a low-probability scenario



Source: National Oceanic and Atmospheric Administration; Climate action tracker - adapted by V. Altounian/Science

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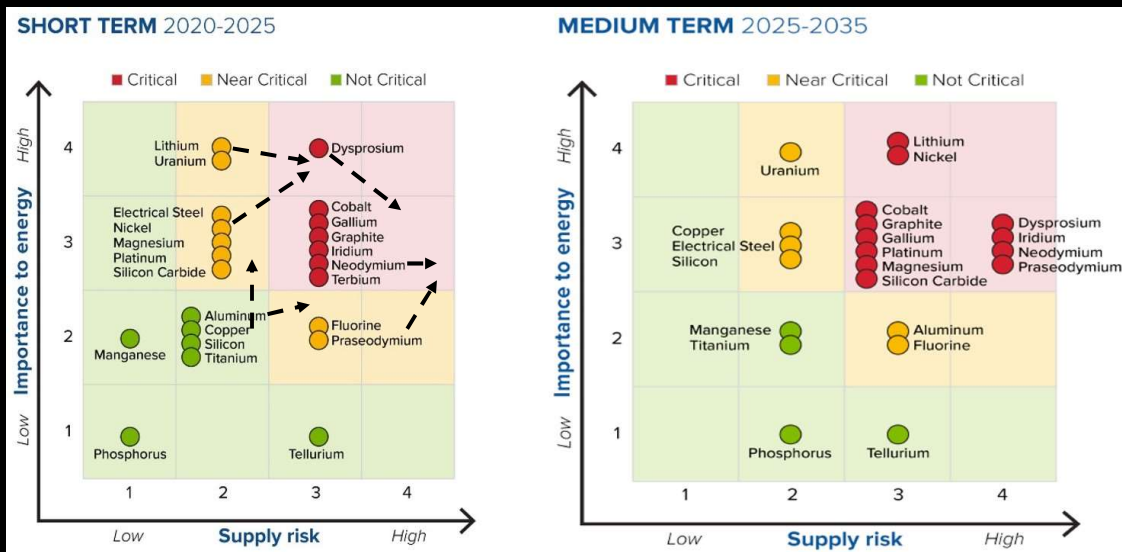
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US adjusts its short- and long-term critical minerals list



Source: US Department of Energy

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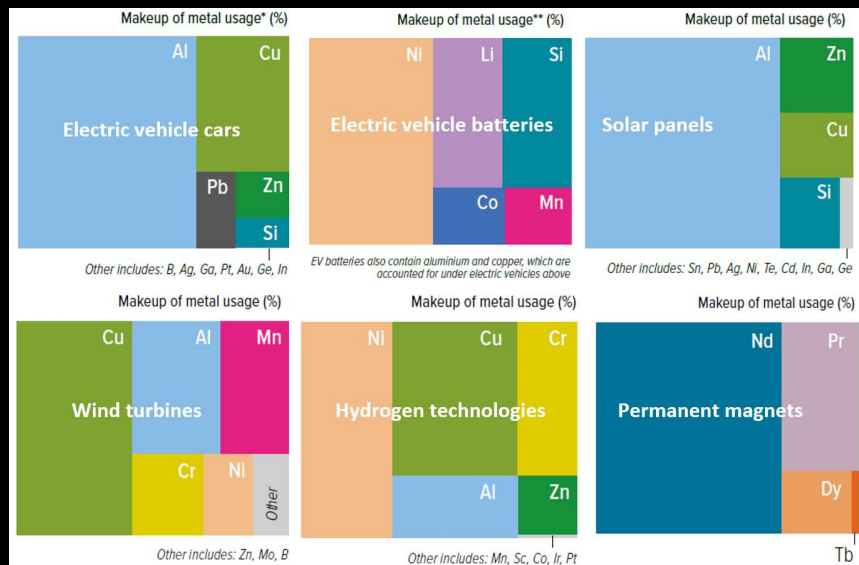
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Source of demand from various low-carbon technologies

- The most used metals in carbon-neutral technologies are:
 - Aluminum (11)
 - Copper (11)
 - Zinc (10)
 - Nickel (10)
 - Manganese (8)
 - Molybdenum (7)
- Electricity networks need a significant amount of Cu and Al, with **Cu regarded as a cornerstone** for all electricity-related technologies by the IEA.
- Copper usage in HEVs and EVs is 2.5x and 4x more than in internal combustion engines, respectively, according to the CDA
- An onshore wind plant requires 9x more mineral resources than a gas-fired power plant

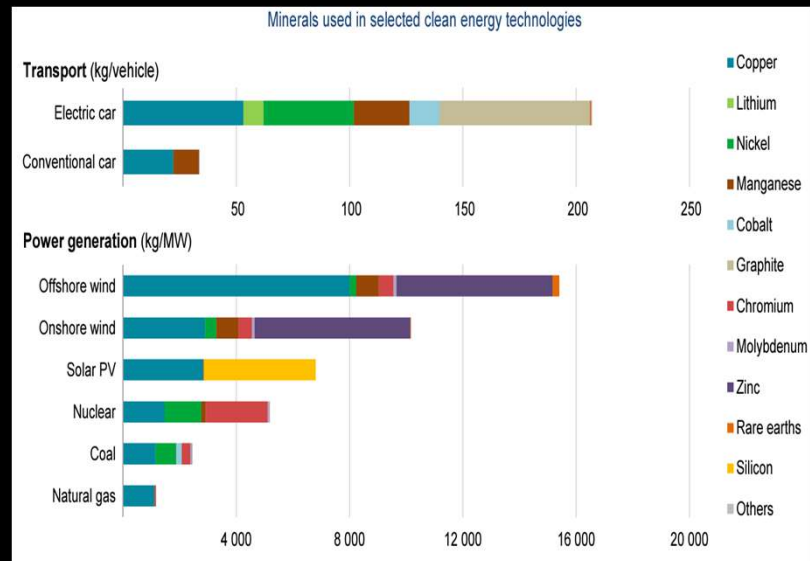


Source: Metals for Clean Energy, Ku Leuven

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Intensity of use for metals in various carbon-neutral technologies

- Significant intensity of metal increase to build EVs versus ICEs (Cu, Mn) and new metals (Ni, C, Li, Co)
- Copper is a base metal required for all technologies but more intense for carbon-neutral technologies (EVs, power generation)
- Nickel is also required for all carbon-neutral technologies
- Zinc required for wind turbines
- Note **technology is not constant** so changes can alter demand trends (i.e. cobalt, DLE)



Source: International Energy Agency

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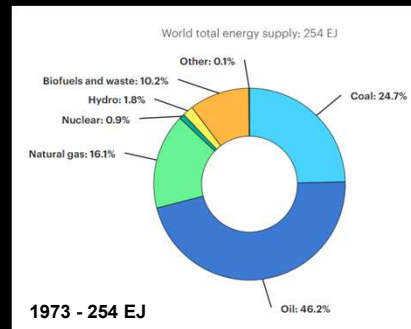
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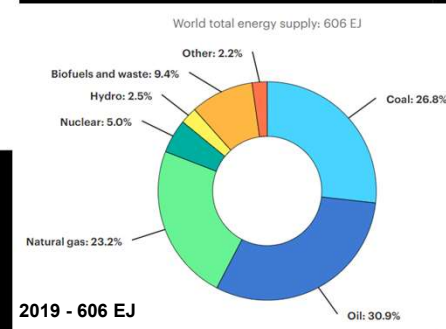
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Renewable energy has been increasing since the mid-2000s

- Global energy demand has increased by 140% since 1973 (45 years)
- In 1973, 87% of the energy sources were carbon-based (oil, coal and natural gas) which fell to 80% in 2019
- Renewables and nuclear accounted for 13% in 1973 and 17% in 2019
- Therefore, most of the growth of demand has been filled by non-carbon technologies



EJ = exajoule = 10^{18} Joule



Source: International Energy Agency

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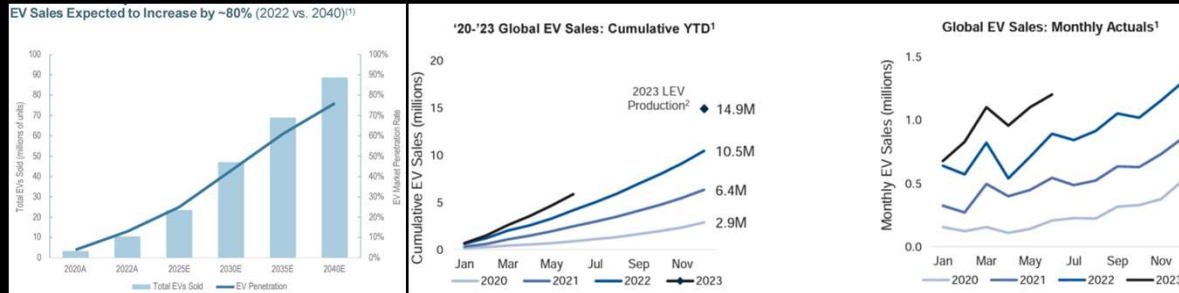
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Ambitious EV growth forecast to 80% penetration by 2040

- The penetration of electric vehicles into the auto market is part of the effort by many regions to meet their ambitious climate goals.
- 2023 global EV sales are estimated to be 14.9 million versus 2.9 million in 2020 (5x increase in 3 years). Sales tend to be weighted to the second half of the year.
- The forecast for 2030 is for the sale of 50 million EVs (45-50% penetration) and 85-90 million EVs (80% penetration) by 2040, which may be **ambitious** given the infrastructure required to power the vehicles and the minerals necessary to build them.



Source: S&P Global and Energy Institute Statistical Review of World Energy 2023

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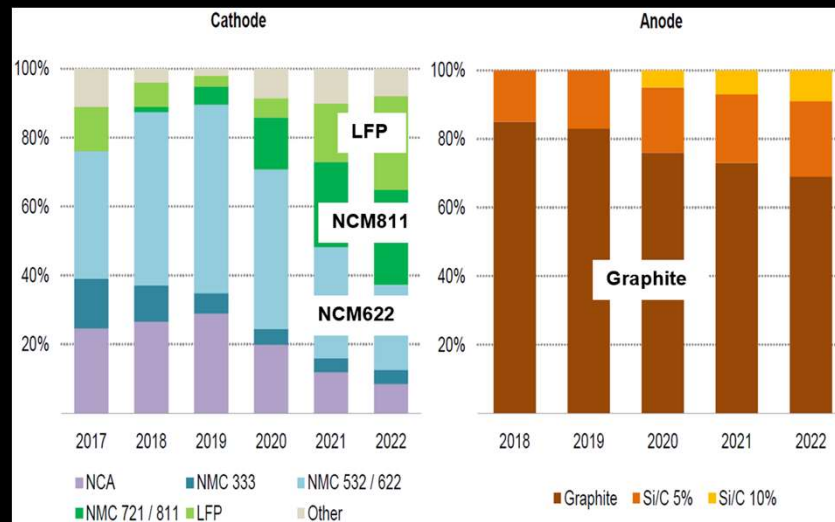
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Changing battery technology in the EV sector

- Demand for battery metals has been **changing** due to technology
- Cathode chemistry is moving away from cobalt (NMC 811), where possible
- Reduction of graphite proportion in the anode



Source: International Energy Agency, Benchmark Intelligence and BNEF

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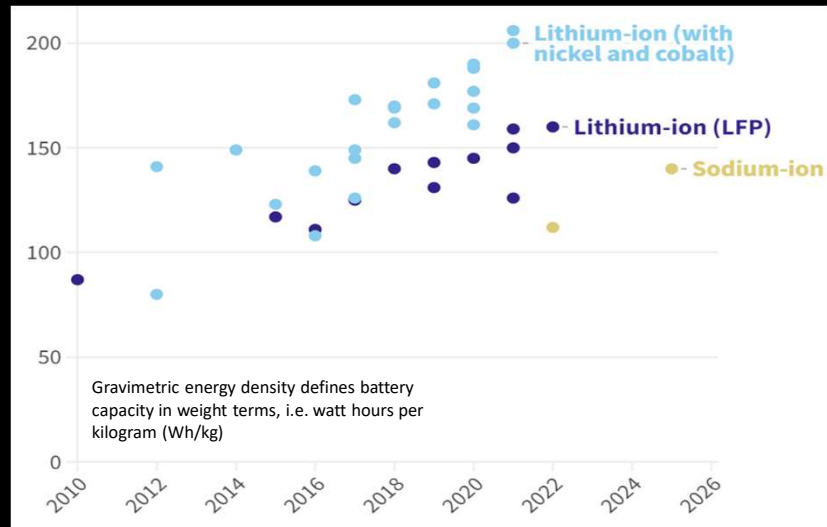
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Incipient technology moving away from lithium, nickel and cobalt

- Increase in lithium-iron phosphate batteries and sodium ion technology
- Less dependence on nickel, cobalt and lithium
- Sodium-ion battery technology is about a decade behind lithium-ion batteries



Source: Casey Crownhart, MIT Technology Review and BNEF


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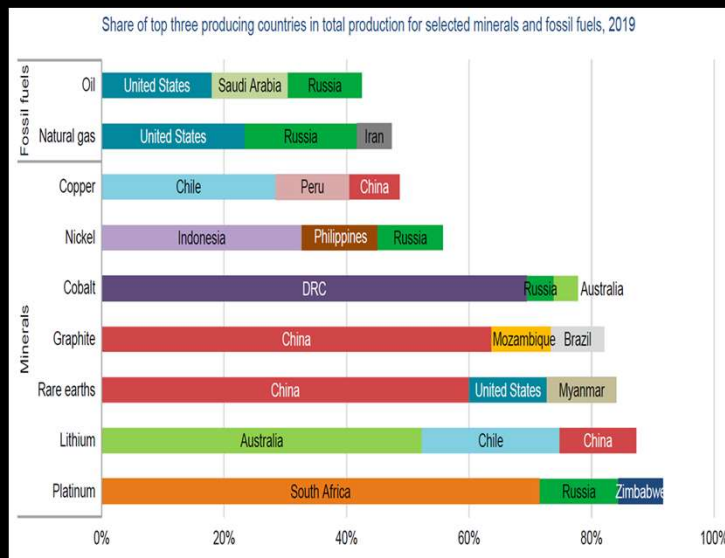
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Western perspective – Cu and Li is apparently ok

- For Western countries (USA, Europe), China's dominance in the production of REE and graphite is problematic as is the concentration of cobalt in DR Congo
- Creeping nationalism** and changing tax agreements in Chile and Peru are a risk to the supply of copper and lithium
- South Africa and Russia's dominance in platinum is only a risk for HEVs



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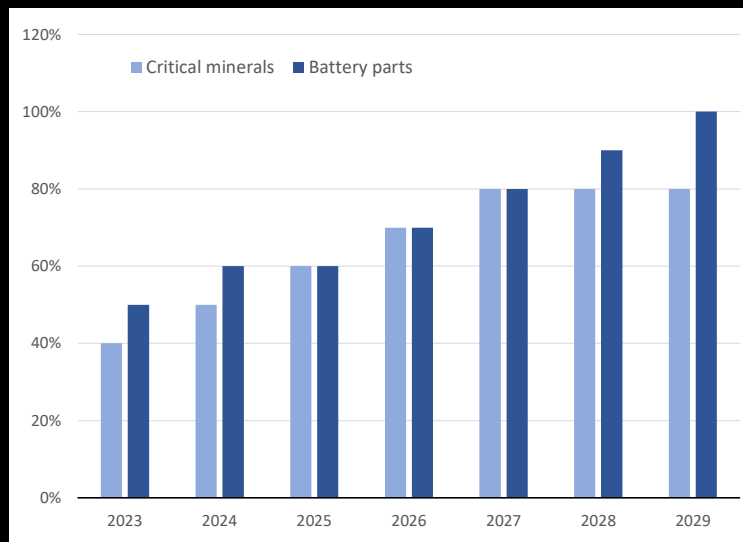
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US EV tax credit focuses on promoting low risk supply

- A new electric vehicle credit whereby US\$3,750 is based on the vehicle having at least 40% of its **battery critical minerals** from the US or FTA countries and rises to 80% in 2027
- Another US\$3,750 is based on the vehicle having at least 50% of its battery **components** coming from the US or FTA countries and rises to 100% in 2029
- Post-act, US demand for critical minerals (Li, Ni, Co, Cu) will be 12-15% higher.
- CAGRs for Li, Ni, and Co to 2035 range between 20-30% driven mostly by EVs while Cu demand will double.



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Securing partners for critical minerals

- Minerals Security Partnership (MSP) was organized between Australia, Canada, Finland, France, Germany, Japan, Korea, Sweden, the UK, the US, and the EU
- The goal is to ensure that critical minerals are **produced, processed, and recycled** to realize the full economic development benefit of their geological endowments.



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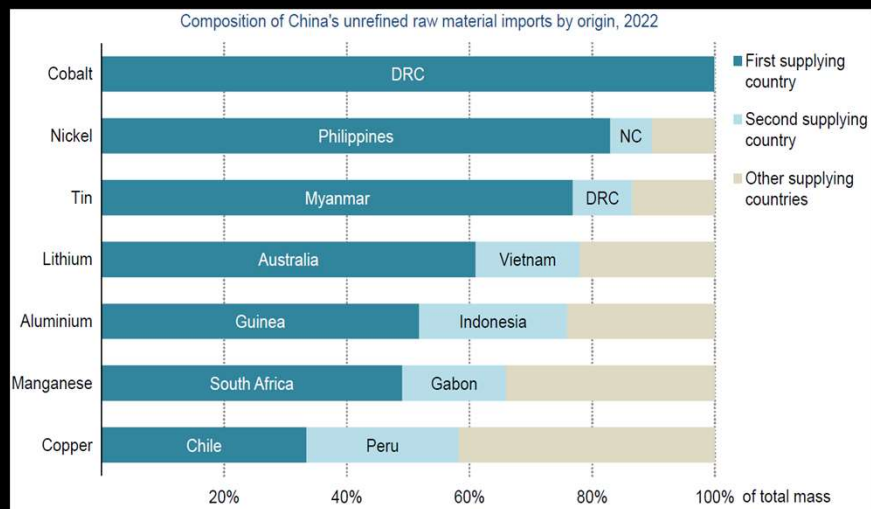
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China's dependence on sources of critical minerals may change

- DR Congo will grow as a source of copper from the large Komoa-Kakula sediment-hosted copper mine
- Australia as a source of spodumene concentrate may be problematic therefore diversification may be important (Bolivia, Argentina)
- China is investing in **downstream battery technology** in Chile (lithium) and Brazil for diversification



Source: International Energy Agency


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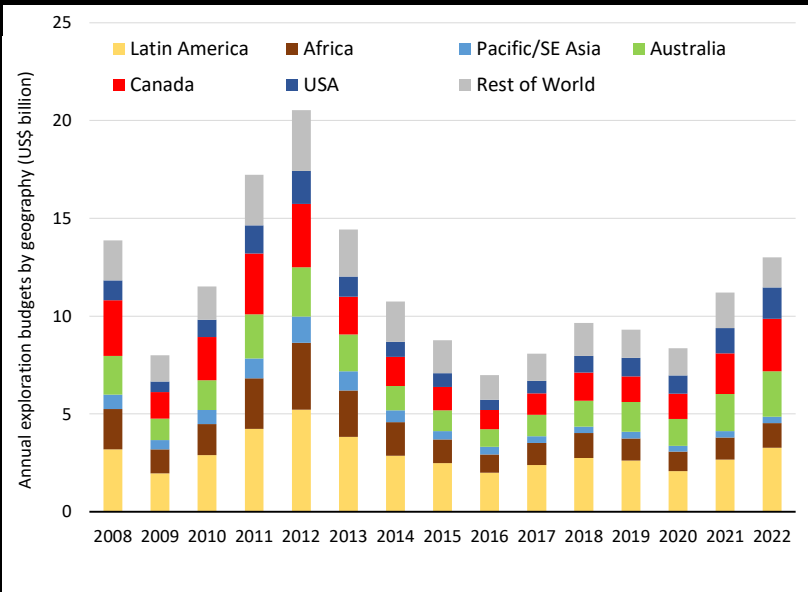
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Trend to 'safe' jurisdictions

- 2022 exploration budget was US\$13 billion for all commodities – 16% higher than 2021 but 63% of the 2012 peak (>US\$20 B)
- Leading the way were 'safe' jurisdictions including the USA, Canada, and Australia, which represented half of the total budget
- These countries were up 22-29% y-o-y and 83-95% of the 2012 peak



Source: S&P Global Market Intelligence and Exploration Insights

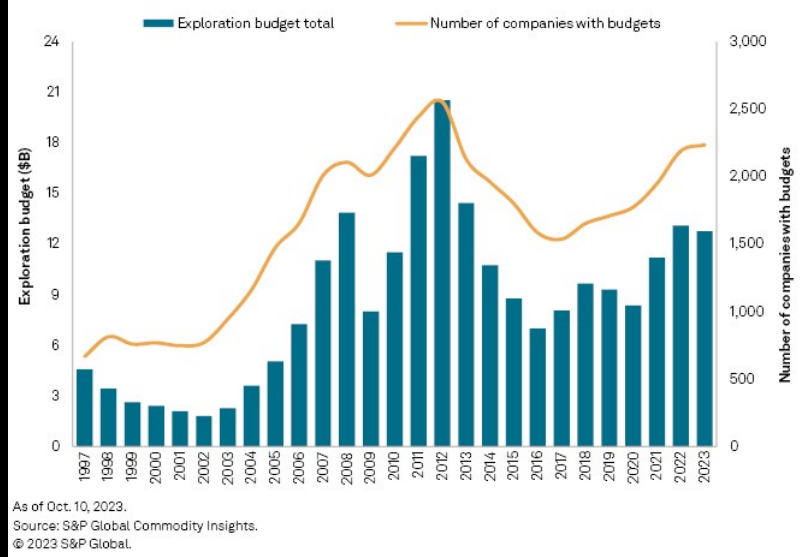
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Exploration trends

- The 2023 global exploration budget was US\$12-13 billion, a slight decline from 2022, 60% of the 2012 peak (>US\$20 B) when 2,500 companies had operating budgets
- Leading the way were 'safe' jurisdictions including the USA, Canada, and Australia, which represented half of the total budget
- The most recent low was in 2016 (US\$6-7 B) with ~900 companies with operating budgets

Annual nonferrous exploration budgets, 1997–2023



Source: S&P Global Market Intelligence

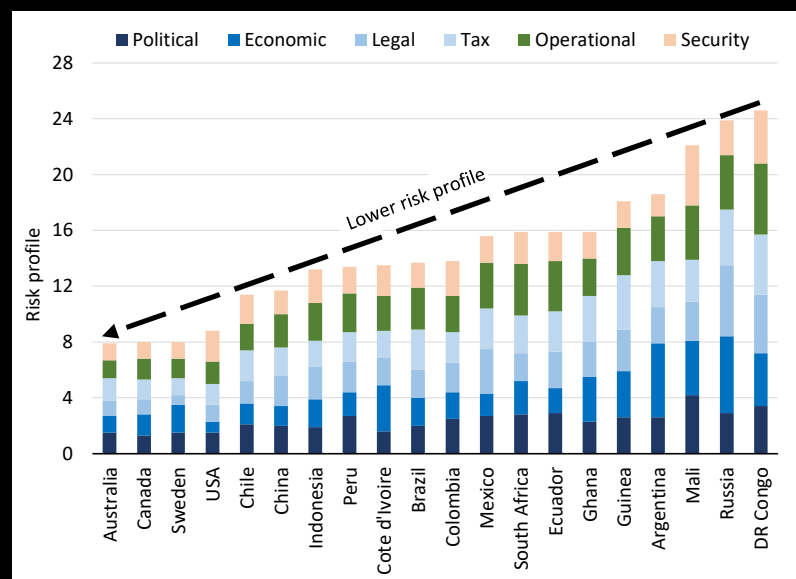
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Canada and USA still lower risk in the Americas

- Australia, Canada and the USA still score the best among the Top 20 destinations for exploration capital
- Most of the risks are higher in other countries such as political, legal, and tax issues
- Despite the political turmoil in Chile and the plan to nationalize its lithium sector, Chile leads important mining countries in Latin America concerning favourable risk profile



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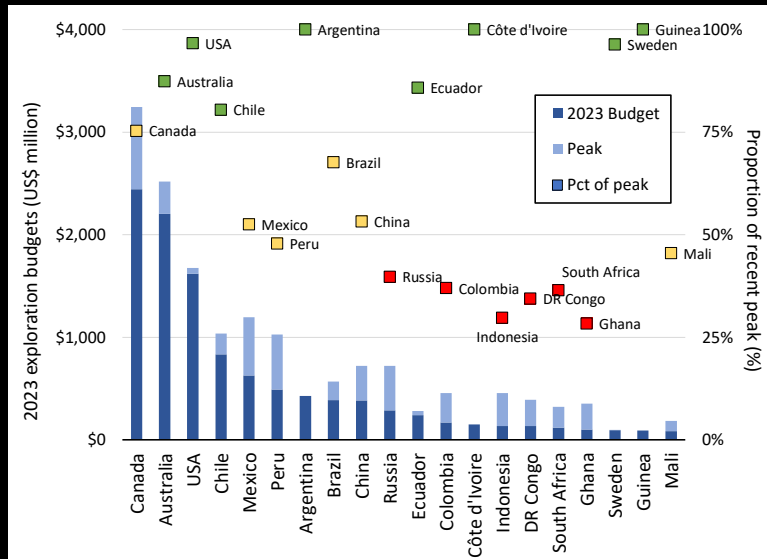
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Canada is at 75% of its recent peak of exploration spending

- New peaks of exploration expenditure include Argentina, Côte d'Ivoire, and Guinea with USA and Sweden at 96-97% at 2012 peaks
- Worst 2023 budgets include Indonesia, Ghana, DR Congo, South Africa, Colombia and Russia (<40% of recent peak)
- Canada's 2023 exploration budget (US\$2.4 B) for all minerals was the largest of all but 75% of its peak in 2012 (US\$3.2 B)
- Flow through financing helps



Source: S&P Global Market Intelligence and Exploration Insights

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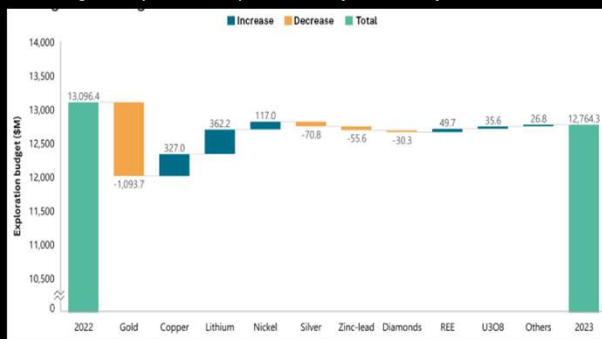
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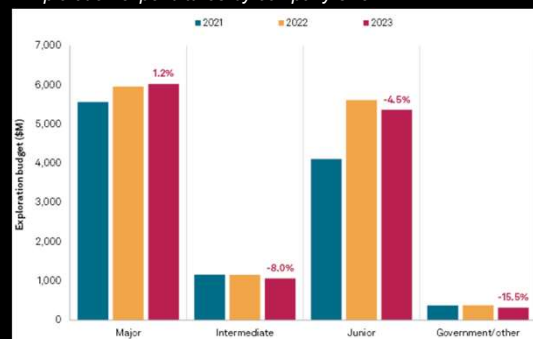
Majors keen on critical minerals while juniors having a hard time

- The 2-3% drop (US\$332 M) in the 2023 exploration budget (US\$12.7 B) versus the previous year (US\$13.0 B) was underpinned by a US\$1.0 billion fall in gold exploration (rising real interest rates), which was offset somewhat by increases in copper (US\$327 M), lithium (US\$362 M) and nickel (US\$117 M) exploration
- Major companies (45-50%) keen on critical minerals increased their budgets to ~US\$6 B in 2023 while intermediate (8%) and junior companies (40-42%) reduced their budgets by 8% and 4.5%, respectively.

Change in exploration expenditures by commodity



Exploration expenditures by company size



Source: S&P Global Market Intelligence

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Funding infrastructure for critical mineral projects

- The **Canada Infrastructure Bank (CIB)** plans to support the critical mineral sector by funding infrastructural projects such as access roads, ports, clean power generation and transmission, and wastewater management facilities.
- The CIB will target individual investments of over C\$100 million and forms part of the CIB's Trade and Transportation priority sector, which has a long-term investment target of C\$5 billion.
- Canada has introduced a tax credit for 30% of the capital cost for infrastructure essential for critical mineral (Li, Co, Ni, C, Cu, and REE) extraction and processing.
- More recently, Critical Mineral Investment Fund will have a capacity of C\$1.5 billion to build clean energy and transportation projects to support critical mineral projects



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Property acquired and available for use	Rate
January 1, 2024 until December 31, 2031	30%
January 1, 2032 to December 31, 2032	20%
January 1, 2033 to December 31, 2033	10%
January 1, 2034 to December 31, 2034	5%

Source: Chris Wattie/Reuters and Lexology.com

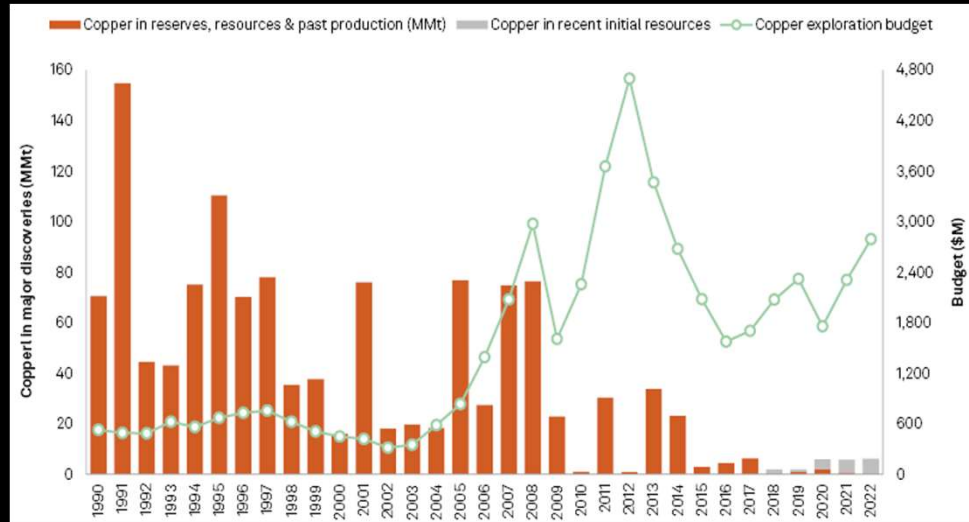
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Higher exploration budget ≠ discoveries

- No significant exploration discoveries in the copper sector one decade after the peak of expenditures in 2012
- Exploration under cover, financing risk for juniors, changing mining laws and sector nationalization



Source: S&P Global Market Intelligence

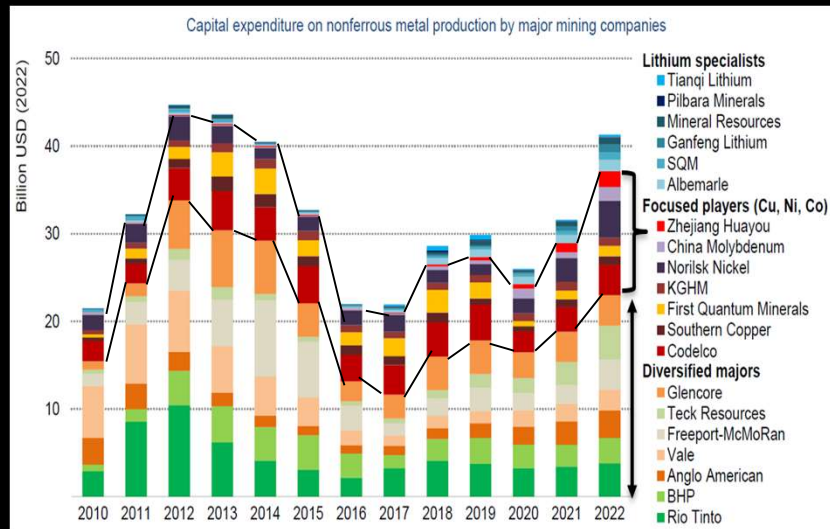
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Capital expenditures for non-ferrous metals are increasing but fall short

- Investment in non-ferrous metals including copper, nickel, cobalt, and lithium has been increasing from ~US\$20 B in 2016-2017
- It has risen almost 2x to US\$40-45 billion in 2022 with participation from all players including diversified miners, focused players, and lithium miners
- The pace has only returned to **2012-2014 levels** and falls short of the pace



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Car makers investing upstream in mining and processing

- GM will invest US\$650 million in the Thacker Pass lithium project in Nevada
- Stellantis allocated US\$155 million to the purchase of a 14.2% stake in McEwen Mining for its Los Azules copper project in Argentina
- Long-term offtakes** do not tend to offer any money upfront or provide much of a project endorsement

Market player	Long-term offtake			Investment in mining			Investment in refining		
	Lithium	Nickel	Others	Lithium	Nickel	Others	Lithium	Nickel	Others
BYD				0	0		0	0	
Tesla	0	0	0				0		
VW Group	0	0			0	0		0	
General Motors	0	0	0	0				0	0
Stellantis	0	0	0	0	0	0			
Hyundai			0						
BMW	0	0	0				0		
Geely Auto									
RNM Alliance	0	0	0		0	0			
Mercedes-Benz	0								


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Source: International Energy Agency

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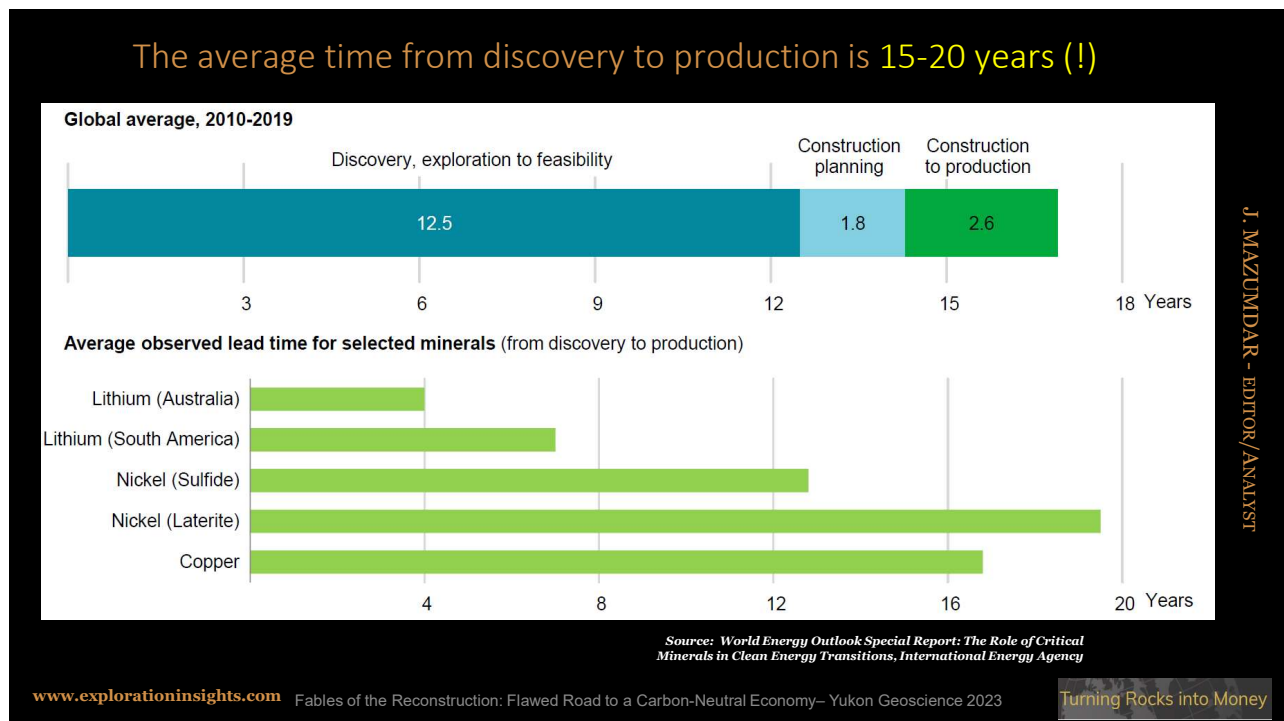
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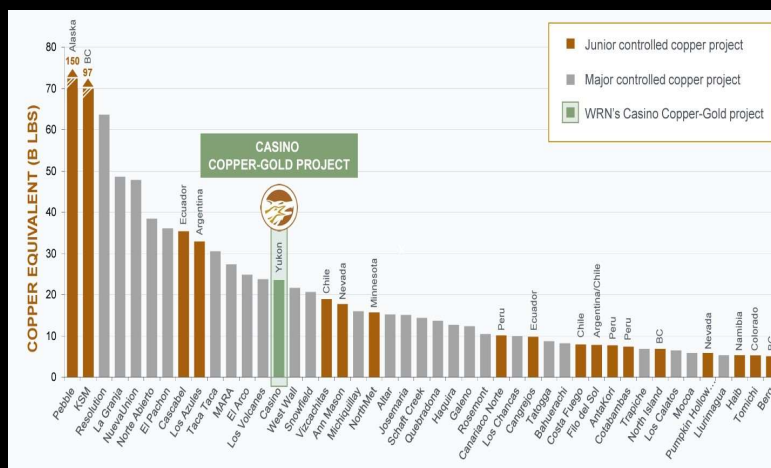


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- The porphyry potential of the Casino project was first recognized in the late 1960s
- Western Copper & Gold (WRN,T, WRN.NYSE) exercised an option on the project in 2007
- 2P reserve (2022) of 1.21 Bt grading 0.19% Cu, 0.22 g/t Ag, 0.021% Mo, 1.7 g/t Ag (0.40% CuEq)
- Could add C\$44.3 B to GDP over its 27-year mine life, create >130,000 FTE positions and pay C\$12.8 B in salaries



Source: Western Copper & Gold.

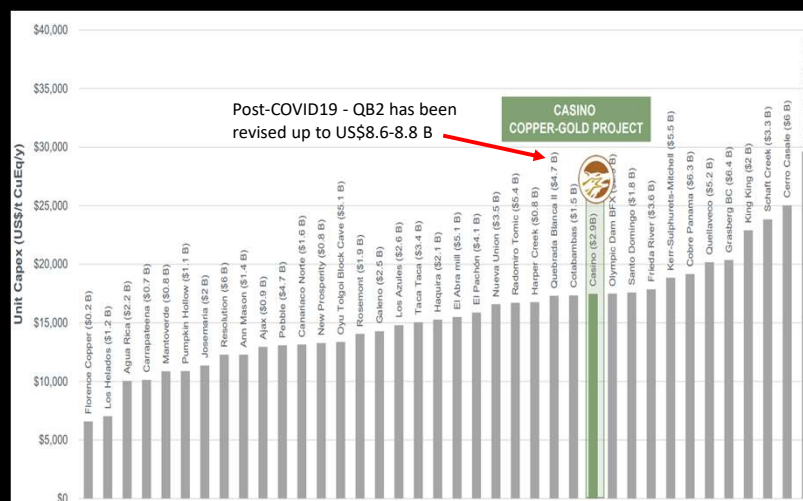
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- The Jan 2013 PFS required C\$2.4 B in upfront capex (120 kt/d)
- Updated June 2022 FS (120 kt/d) needs C\$3.6 B in capex (+50%)
- Its **low grade** (0.19% Cu) and **semi-remote location** supports a high capex intensity
- But the QB2 porphyry Cu project is in construction (Teck) and Capstone is keen on the permitted Santo Domingo IOCG FS-stage, also in Chile.



Source: Western Copper & Gold.

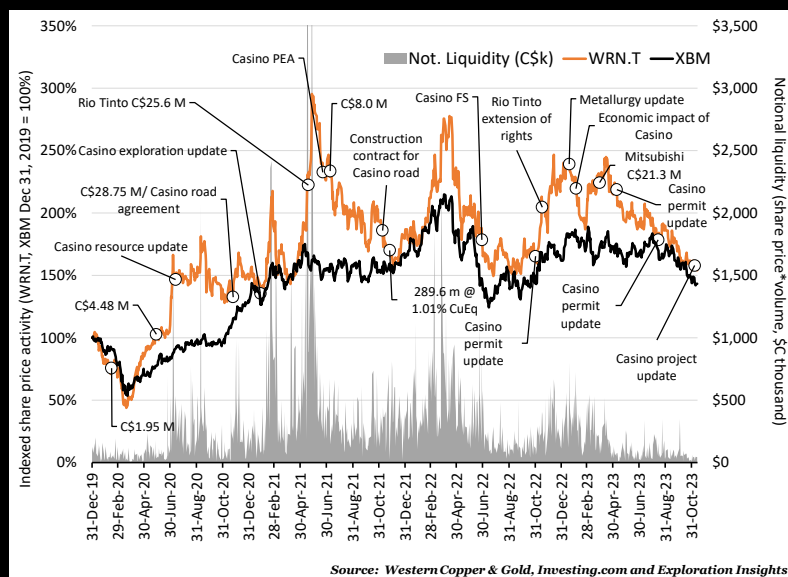
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In the orphan period

- Over the past few years, WRN has been on the path to development which is considered the 'orphan period' for junior miners, with **elevated financing risk**
- The project did attract major industry players including **Rio Tinto** and **Mitsubishi** to support its technical progress (feasibility study, metallurgy, infill drilling, permitting)



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A road to somewhere

- In August 2019, the Yukon Territorial Government and the Little Salmon/Carmacks First Nation agreed on the proposed first section of the Casino Project Access Road known as the Carmacks Bypass (82 km).
- Sourced from an overall fund of C\$300 M, the Federal and Yukon government would fund 100% of the Carmacks Bypass. The government has spent C\$30 M on a bridge and 5 km of road, ahead of schedule. There is more road to build.
- The next leg of the access road (132 km) is 30% funded by the government
- The 2013 FS cost estimate was C\$90 M for the access road with a 50% escalation, **the current estimate may be C\$135 M**



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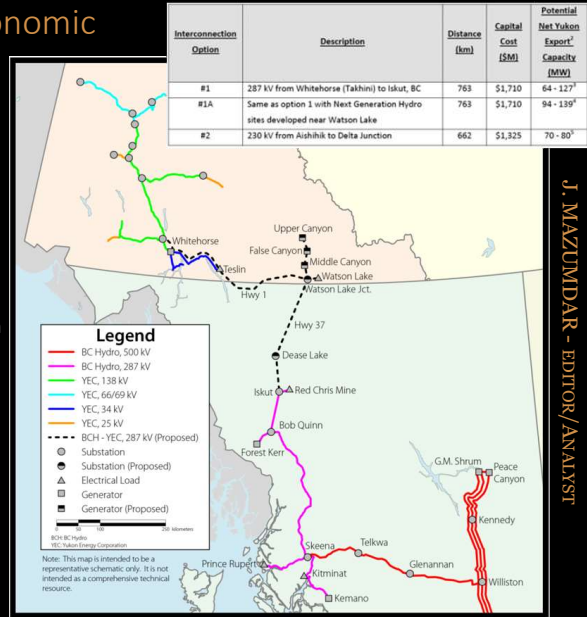
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Getting on the grid is uneconomic

- About a third (C\$2.05/t) of the process costs (C\$6.42/t of ore) are linked to power assuming a cost of C\$0.098 kW/h with an LNG source. 2013 FS est. was C\$209 M for the power plant (not installed, C\$313 M?)
- Most of the power costs are linked to crushing, conveying and grinding (14.5 kWh/t, 200 µm primary, 25 µm regrind) to achieve >90% Cu recovery
- If connected locally, the Casino project would put a 130 MW load on the Yukon grid (200 MW of capacity). But in 2019, the capacity of the Yukon grid was 136 MW with 80% hydroelectric power and the remainder from natural gas and diesel
- According to the Energy Corporation last week, the current dependable capacity gap for Yukon is 37 MW. Yukon's peak demand for electricity is forecast by YEC to grow by 36% between now and 2030.
- Note that the 2022 Casino FS includes C\$1.86 billion in carbon tax of C\$170 per tonne of carbon by 2030 above a threshold
- The transmission lines (763 km) required to connect the Yukon to either BC are very long and costly to build (C\$1.7 B). Current studies suggest it is not economic (-C\$1.4 B).



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Skagway port facility needs refurbishment

- The port facility at Skagway is about 560 km from the Casino project and previously shipped concentrates from Minto Mine
- Yukon government signed an MOU with the port facility in March 2023
- The upgrades that are the responsibility of the Port of Skagway include:
 - replacement of the ship loader
 - extension of the existing conveyor and repair or replacement of the existing dock.
 - new Load-out Facility with the capability to store 30-40 kt of concentrate.



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First concentrate production by 2030 from Casino

- WRN plans to submit the ESE statement for Casino in Q4/2024.
- The ESE Statement forms the basis for the Company's assessment application for the Panel Review
- It will include all the material outlined in the Revised ESE Statement Guidelines
- Selkirk (SFN) and Little Salmon/Carmacks First Nations (LSCFN) Groups

	2026				2027				2028				2029				2030			
	Year -4				Year -3				Year -2				Year -1				Year 1			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Full Notice to Proceed																				
One lane access road construction																				
Existing camp relocation																				
Mass excavations with mining fleet																				
Mining																				
Two lane access road construction																				
Second phase construction camp																				
Heap leach circuit construction																				
Heap leach gold production																				
Concentrator construction																				
Concentrate production																				

Source: Western Copper & Gold

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Minto abandoned by owners but fail-safes in place

- The Minto copper mine also sits in the Selkirk First Nations
- Its former owner without much warning abandoned the mine on May 12 but left C\$75 million in a security fund for reclamation liabilities.
- The Yukon gov't has plans to spend about C\$20-21 million by May 2024
- But unpaid contractors are lining up for another C\$66 million



Source: Government of Yukon


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- What is a critical mineral?
- Demand for critical minerals
- Sources of critical minerals
- Exploration, capex and financing trends
- Yukon example – Casino copper-gold porphyry
- **ESG risk**
- Processing capacity
- Summary & Conclusions

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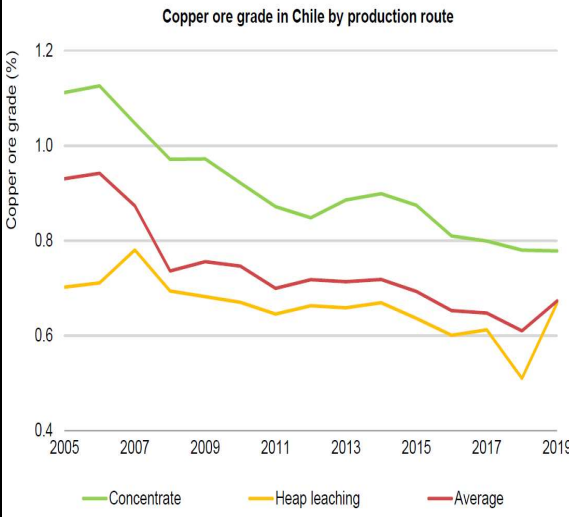
39

Falling grades lead to higher energy usage creating an ESG loop

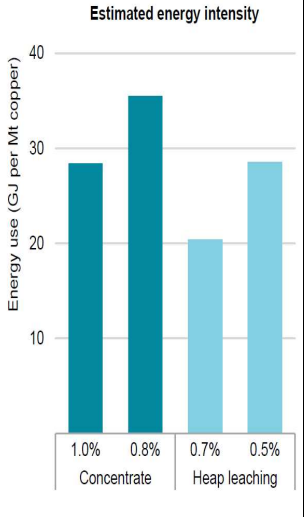


- Copper grades are **declining** as lower-grade deposits become economic at higher prices
- Copper sulphide deposits generate concentrates that have higher **energy intensity** than those leached on pads with SX/EW
- The copper smelting capacity is concentrated in China which raises another concern (more coal power)

Copper ore grade in Chile by production route



Estimated energy intensity



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Source: World Energy Outlook Special Report: The Role of Critical Minerals in Clean Energy Transitions, International Energy Agency

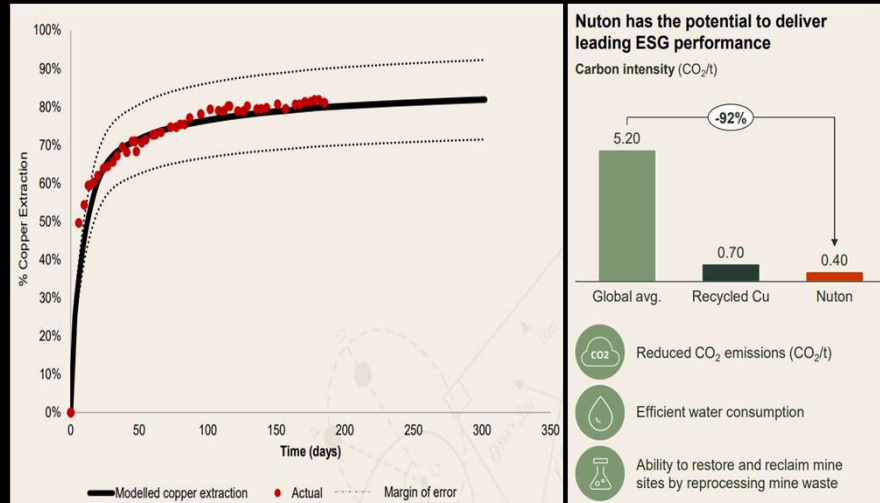
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Copper leaching technology is advancing

- Rio Tinto's Nuton copper leaching technology is forecast to replace concentrates in certain deposits
- **Leaches copper** (80% recovery?) to produce copper cathode and avoids a smelter
- Generates fewer carbon emissions and consumes less water but is not a 'one size fits all'



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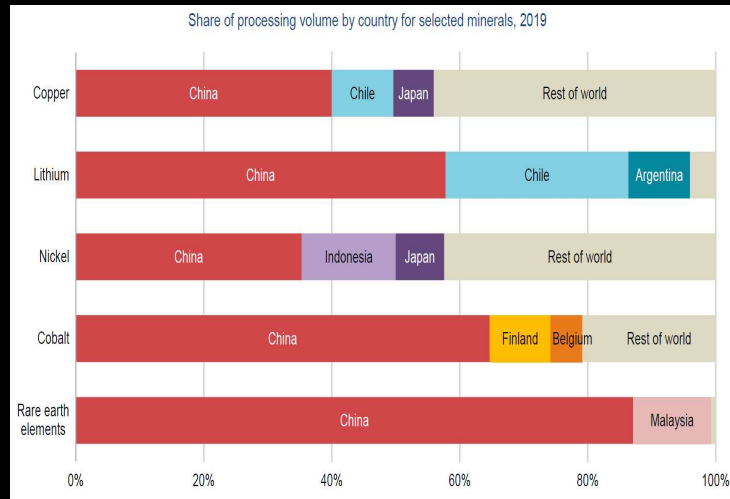
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China dominates the processing of critical minerals

- The 'Commodity Supercycle of the 2000s' was underpinned by an inexhaustible demand for minerals in China
- During that time China has built up its smelting and refining capacity in the majority of critical minerals
- Even if the US mines the copper, lithium (ex. Thacker Pass), nickel, and REE, the product is not finished and still needs to be processed further for the battery sector
- Unfortunately, most of that capacity is in China



Source: World Energy Outlook Special Report: The Role of Critical Minerals in Clean Energy Transitions, International Energy Agency

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Summary & Conclusions

- Critical minerals are those required for the energy transition to a carbon-neutral world
- What is considered critical depends on the regional demand and supply
- Source of demand are the metal-intensive green technologies including renewable power sources and electric vehicles
- The supply of critical minerals depends on where it is destined for. There is a difference between sources for the US/Europe and China.
- Exploration trends are negatively impacted by financing risk for juniors
- Capital expenditures are not meeting needs for supply growth

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Summary & Conclusions

- There are a variety of funding sources for critical mineral development projects (government, car manufacturers)
- Development timelines (permitting) are long from discovery to production (15+ years) as reflected in the Casino copper-gold project in the Yukon
- Infrastructure is important for many projects (access roads, power, water)
- Lower-grade projects generate a higher carbon footprint
- Alternatives to smelting but project dependent
- Processing capacity weighs in favour of China with a multi-decade head start

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- Independent, unbiased, and technical commentary on the *mining sector*
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Joe Mazumdar – Geologist (10 years), commodity analyst & trader, equity analyst (9 years), corporate dev/strategic planning (4 years)

- Noranda, MIM, RTZ, North, IAMGold,
- Phelps Dodge, Newmont
- Haywood, Canaccord Genuity
- Canada, Australia, Argentina, Chile, Peru, Ecuador, USA



Brent Cook - Independent exploration analyst with over 30 years of experience in both property economics and geology evaluations

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