

 **UM6P
SCIENCE
WEEK**




NEXUS
National Exploration
Undercover School



Dr. Richard Lilly
NExUS Program Leader
University of Adelaide
(2015-2025)

6th July 2026



The Mine of the Future

Mining is a BIG topic

WHY?

WHAT?

WHERE?

HOW?

WHO?

The Mine of the Future



WHY?

WHAT?

WHERE?

HOW?

WHO?

Why do we Mine?

WHY?

WHAT?

WHERE?

HOW?

WHO?

Humans have always mined earth resources

turkanabasin.org

**Oldest Stone
tools: 3.3 Ma
(Lake Turkana,
Kenya)**

**Pre-dating genus
Homo by 0.5 MA**

**1 – 0.5 Ma
Acheulean
(Africa-Europe)**



**Oldest Mines: 42,000 years
Ngwenya, Swaziland
Hematite ochre**



**Oldest metal tool:
~7,000 years
(Middle East)**

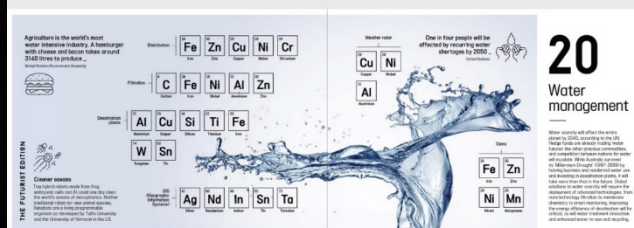
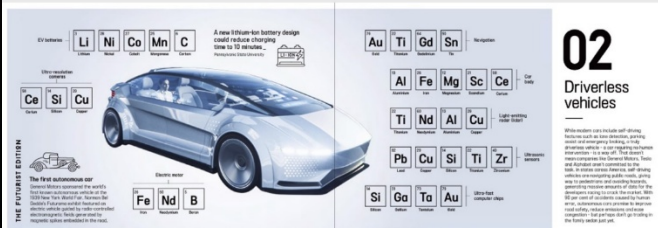
WHY?

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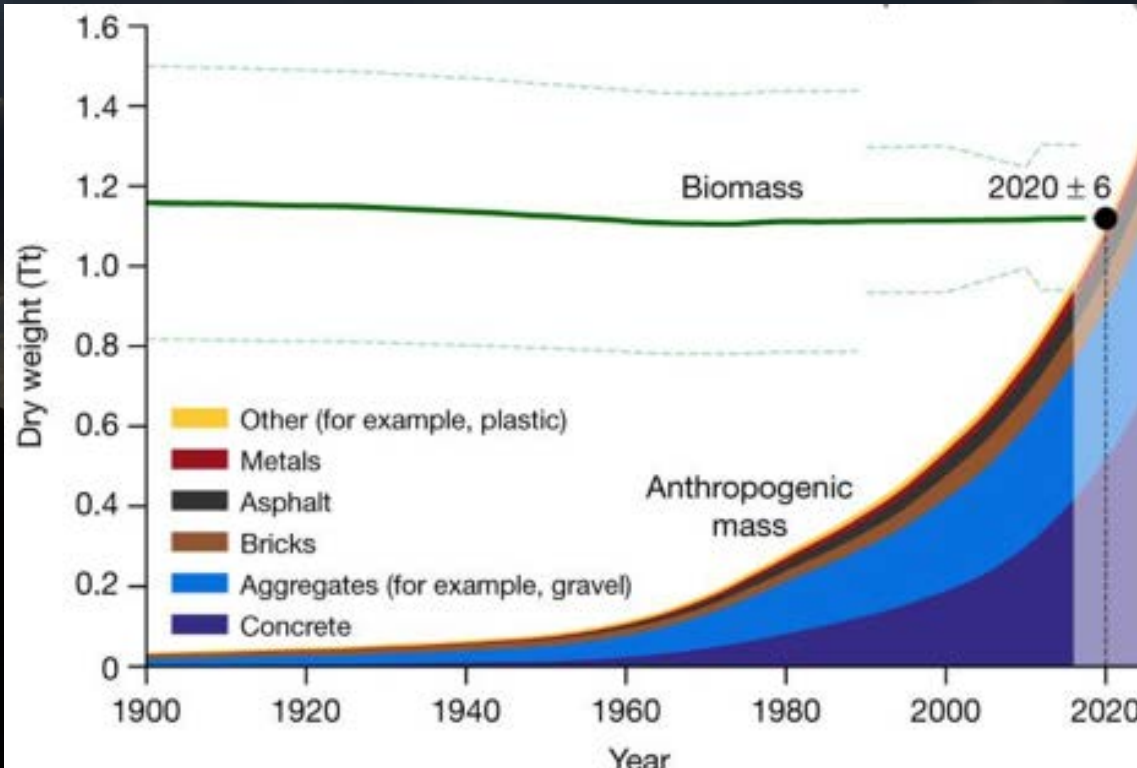
WHY?

WHAT?

WHERE?

HOW?

WHO?



<https://www.nature.com/articles/s41586-020-3010-5>

nature

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Article | Published: 09 December 2020

Global human-made mass exceeds all living biomass

[Emily Elhacham](#), [Lied Ben-Uri](#), [Jonathan Grozovski](#), [Yinon M. Bar-On](#) & [Ron Milo](#) [✉](#)

[Nature](#) 588, 442–444 (2020) | [Cite this article](#)

The volume of human-made materials on the planet now exceeds the volume of biomass on the planet

And it is speeding up...

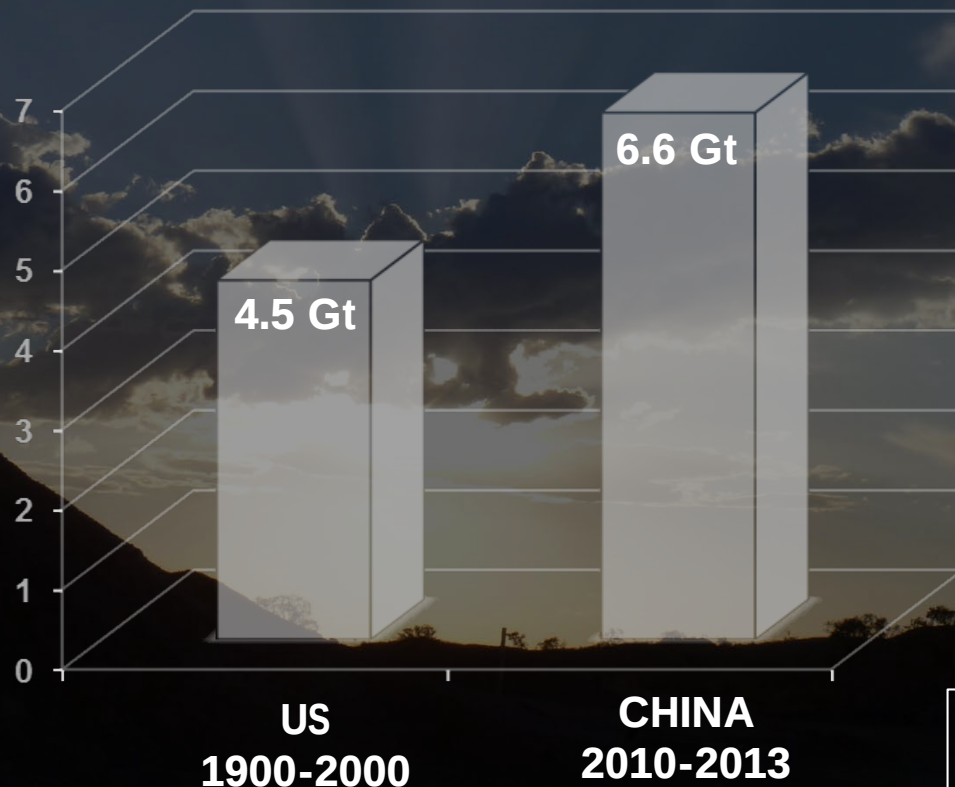
WHY?

WHAT?

WHERE?

HOW?

WHO?



Larry Meinert, USGS, 2015

**‘Between 1900 and 2000
the United States used
4.5 billion tons of cement.**

**In 3 years between 2010
and 2013 China used
6.6 billion tones of cement’**

**Q: What is the most mined
commodity in the world?**

A: SAND

**~50 Bt per year = 18kg+ for EACH person,
EVERY DAY**

WHY?

WHAT?

WHERE?

HOW?

WHO?



Think about all the resources in those buildings...in one part of one city in one country...and it's India and Africa's turn next...

WHY?

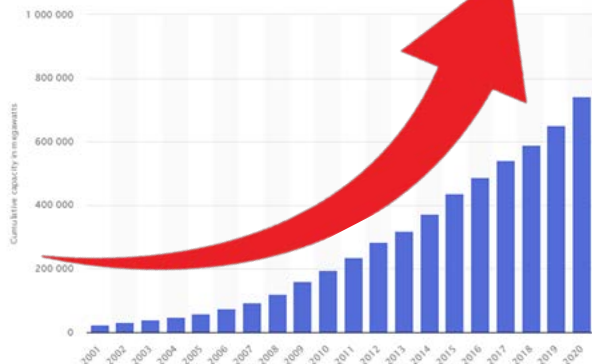
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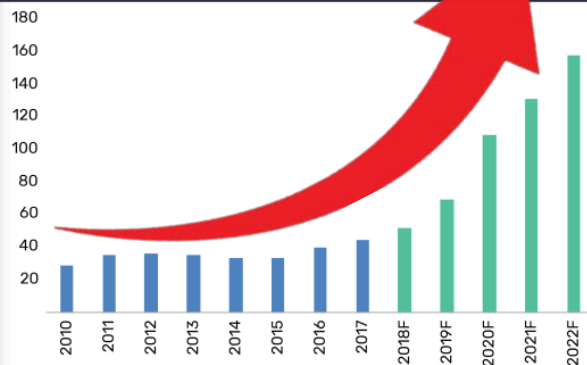
HOW?

WHO?

Energy & Environment • Energy
Global cumulative installed wind power capacity from 2001 to 2020
(in megawatts)

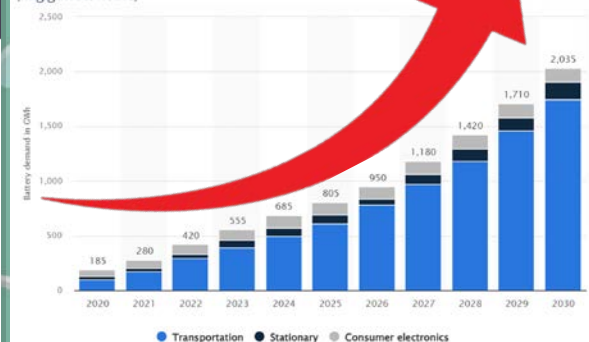


Global lithium production
(kt), 2010–2022



Source: GlobalData, Mining Intelligence Center

Projected global battery demand from 2024 to 2030
(in gigawatt-hours)



<https://www.statista.com/statistics/1103218/global-battery-demand-forecast/>

Population is growing faster than at any time in history

Mineral consumption is growing faster than population

GREEN ENERGY



WHY?

WHAT?

WHERE?

HOW?

WHO?

What do we Mine?

WHY?

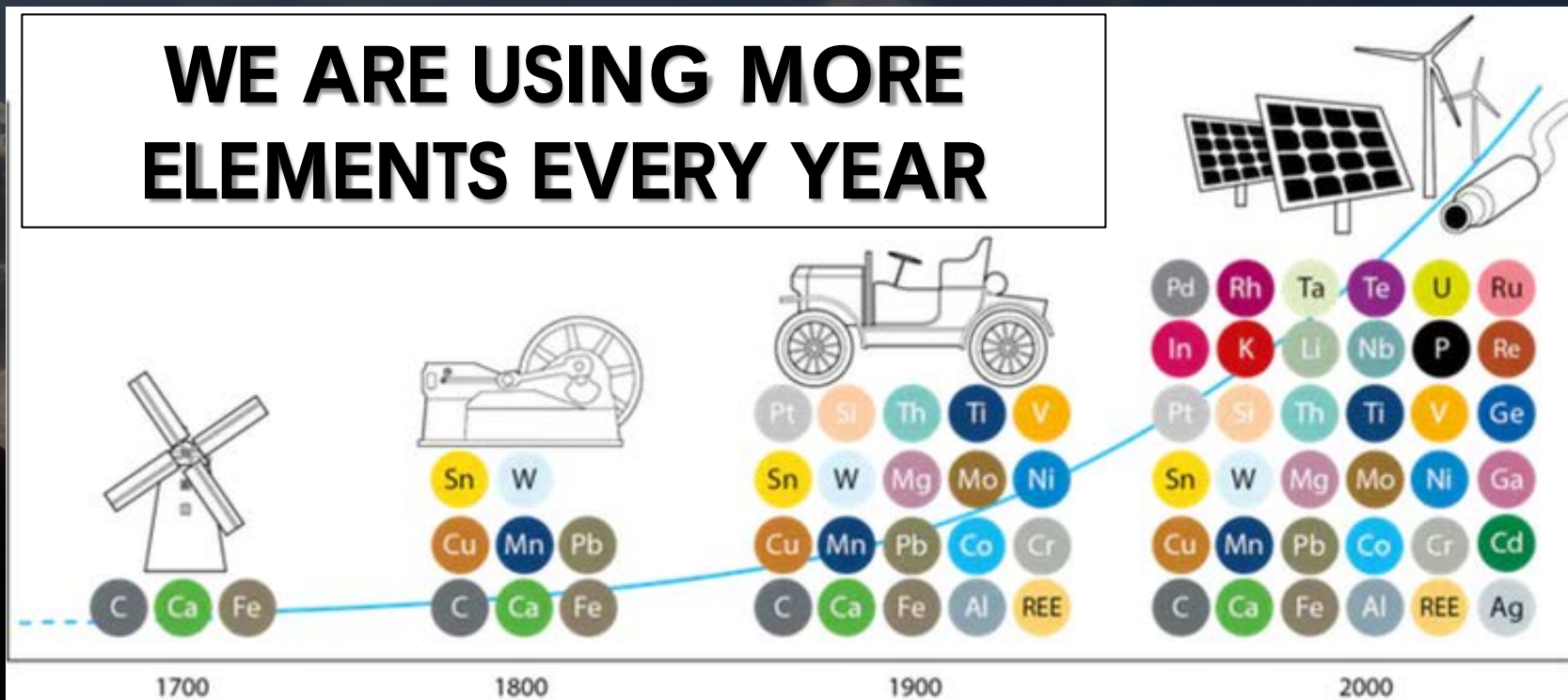
WHAT?

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WE ARE USING MORE ELEMENTS EVERY YEAR



WHY?

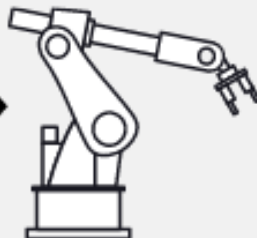
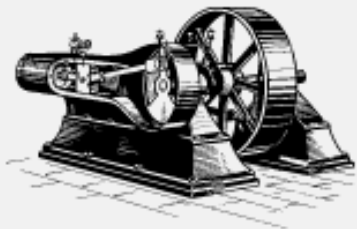
WHAT?

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WHO?

We are entering the 5th Industrial Revolution

**Industry 1.0**

mechanization,
water and steam
powers

1800**Industry 2.0**

mass production,
electric power,
assembly line

1900**Industry 3.0**

computers,
automated
production,
electronics

2000**Industry 4.0**

cyber-physical
systems, IoT,
networking,
machine learning

2010**Industry 5.0**

human-robot
collaboration,
cognitive systems,
customization

2025+

Global
Population:

1 Bn**1.6 Bn****6.5 Bn****8 Bn+**

WHY?

WHAT?

WHERE?

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WHO?



‘In 1995 a mobile phone used ~30 elements, in 2025 a mobile phone uses ~75 elements’

Larry Meinert, USGS, 2015

‘We had no way of predicting the huge rise in demand for these additional elements’.

‘Which elements will be in demand in 20 years from now?’

‘Where will we source them from?’

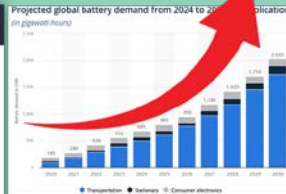
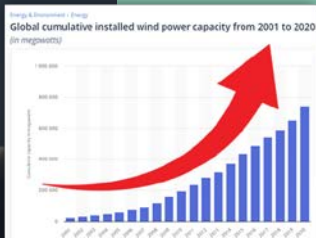
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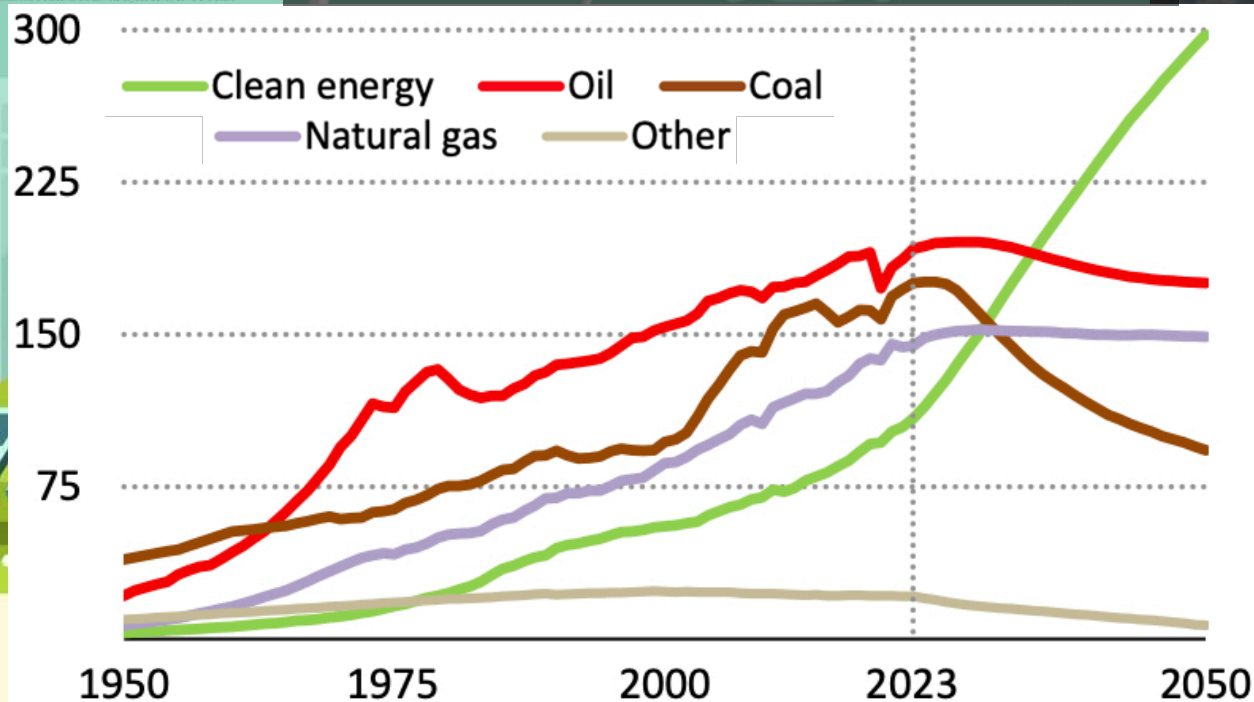
WHO?



World Energy Outlook 2024

(International Energy Agency 2024)

Global shift to renewable energy will require more resources than ever before



WHY?

WHAT?

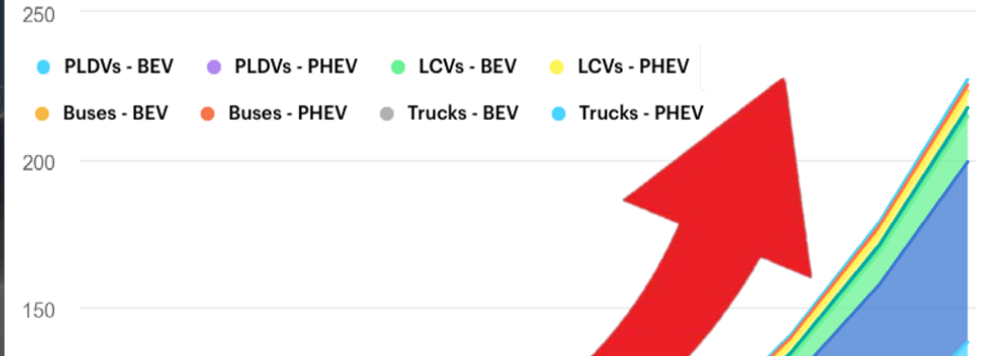
WHERE?

HOW?

WHO?



Global EV Outlook 2021 (International Energy Agency)



Copper

Minerals used in selected clean energy technologies

Transport (kg/vehicle)

Lithium

Manganese

REE and others

Electric car

Conventional car

Nickel

Cobalt

50

100

150

200

WHY?

WHAT?

WHERE?

WHO?

Metal Usage: How Much Copper

Regular internal
combustion engine car
(Dacia)



~20-25kg

Hybrid petrol/electric car

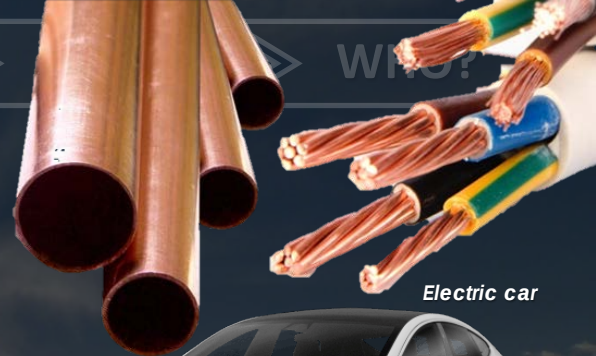


~40-60kg

Electric car



~80-100kg



~6g

(older models
~15-20g)



~100kg



~4,000kg



~7,300kg

Up to ~30,000kg
(30t) (!)



(Newer models ~4t)

WHY?

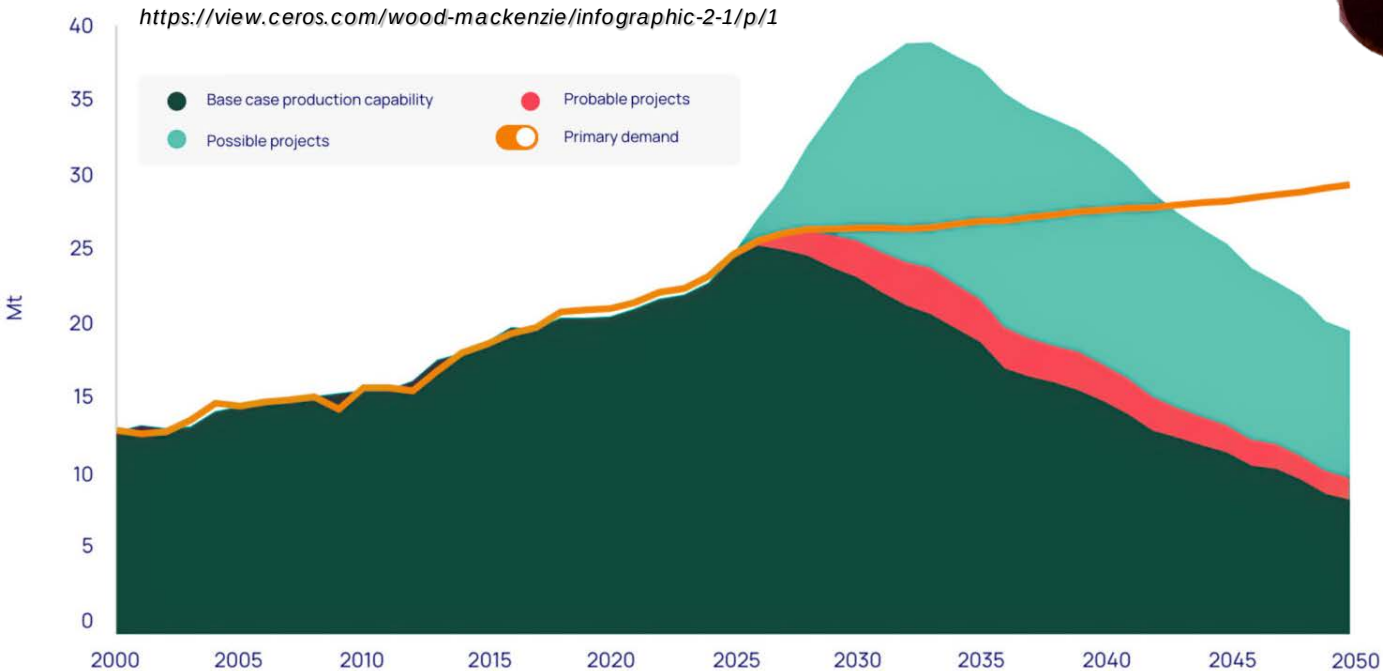
WHAT?

WHERE?

WHO?



Global Copper Production and Primary Demand



In last 25 years we have used HALF of the copper ever mined

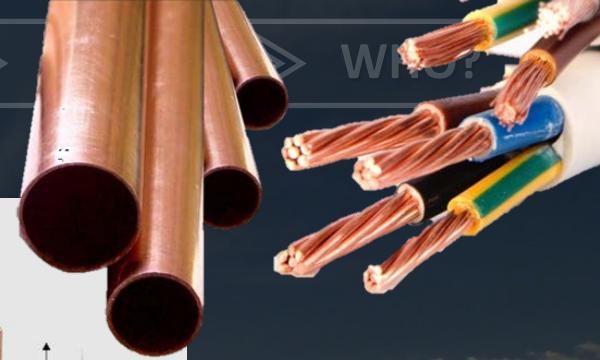
During the next 25 years we will have to DOUBLE the 700Mt of Cu ever mined.....

WHY?

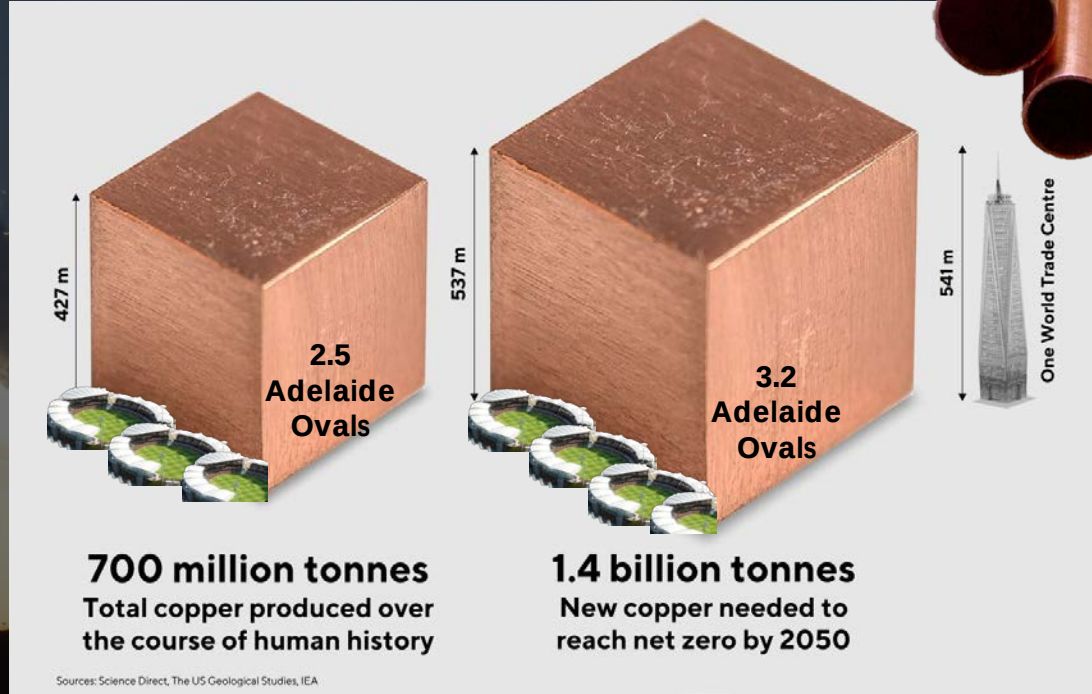
WHAT?

WHERE?

WHO?



Global Copper Production and Primary Demand



Is this sustainable?

During the next 25 years we will have to **DOUBLE** the 700Mt of Cu ever mined.....

WHY?

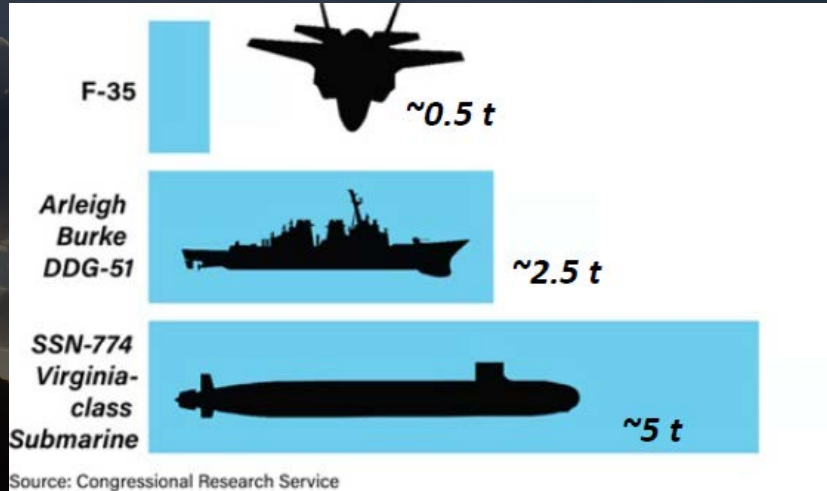
WHAT?

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HOW?

WHO?

Rare Earth Elements



Predicted Global Defence Spending: ~\$2.5 Trillion USD

Last 10 years has seen a surge in demand for REE

Predicted Global Green Technology Demand: \$0.5 Trillion USD



REE supply chain is heavily politicised

WHY?

WHAT?

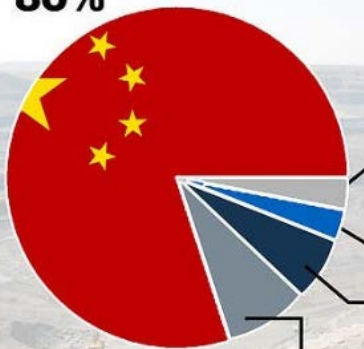
WHERE?

HOW?

WHO?

US RARE EARTH SUPPLIERS

CHINA
80%



OTHERS
8%

US Ge...

China Just Turned Off U.S. Supplies Of Minerals Critical For Defense & Cleantech

April 5, 2025 3 days ago Michael Barnard

Why it's nearly impossible for America to meet its rare-earth needs after China's export restrictions

U.S. inaction on rare earths gives China 'very powerful currency at the negotiating table,' says CSIS researcher

By Myra P. Saefong [Follow](#)

Last Updated: April 16, 2025 at 10:19 a.m. ET

First Published: April 15, 2025 at 5:02 p.m. ET

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Listen (8 min)

Reciprocal Tariffs		
Country	Tariffs Charged by the U.S.	U.S.A. Discounted Reciprocal Tariffs
China	67%	34%
European Union	39%	20%
Vietnam	90%	46%
Taiwan	64%	32%
Japan	86%	24%
India	52%	26%
South Korea	50%	25%
Thailand	72%	36%
Switzerland	61%	31%
Indonesia	64%	32%
Malaysia	47%	24%
Cambodia	97%	49%
United Kingdom	10%	10%
	60%	30%



REE supply chain is heavily politicised

WHY?

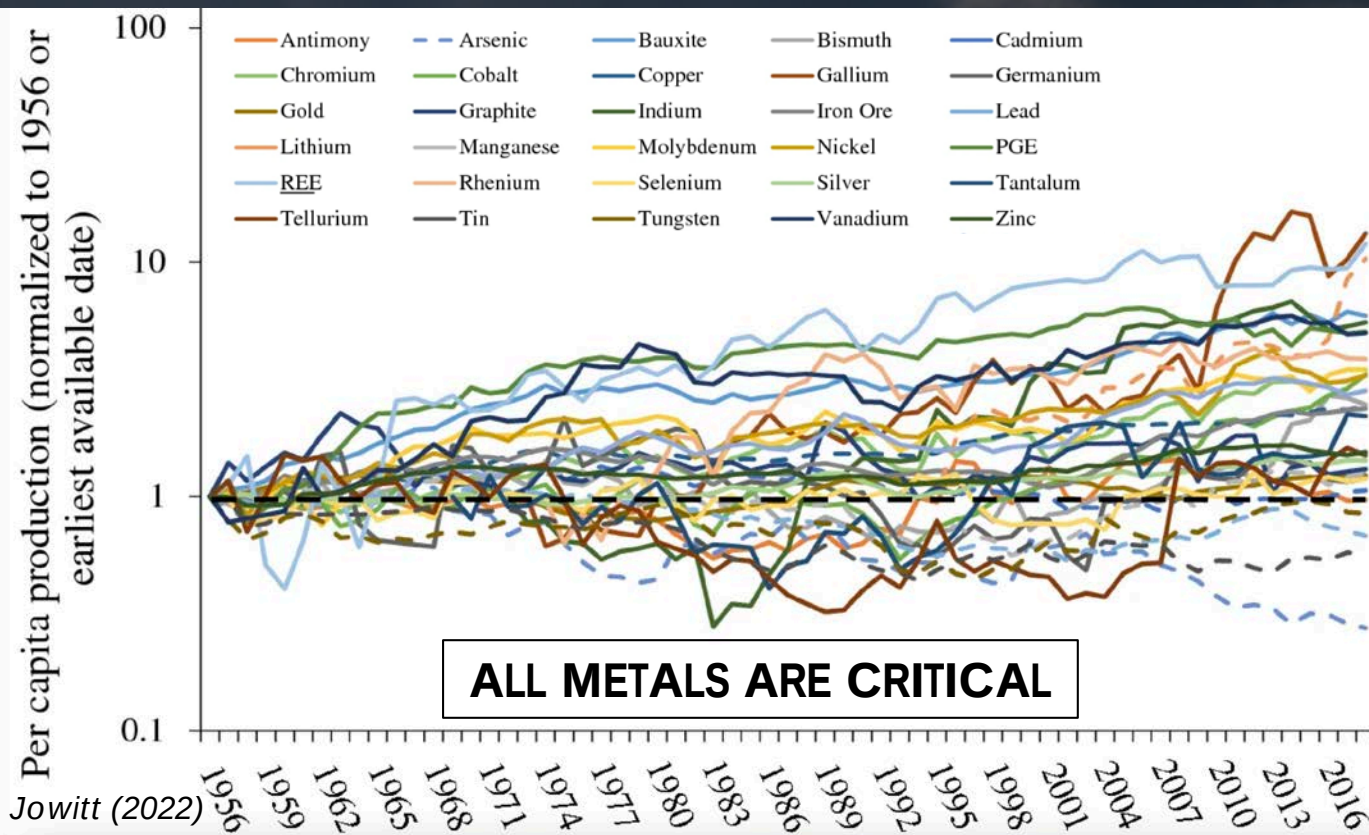
WHAT?

WHERE?

HOW?

WHO?

Global metal use is on the increase



**DEMAND FOR
ALL METALS IS
INCREASING:
ALL METALS
ARE NOW
CRITICAL**

**WHERE WILL
WE SOURCE
THEM FROM?**



WHY?

WHAT?

WHERE?

HOW?

WHO?

Where will we Mine?

WHY?

WHAT?

WHERE?

HOW?

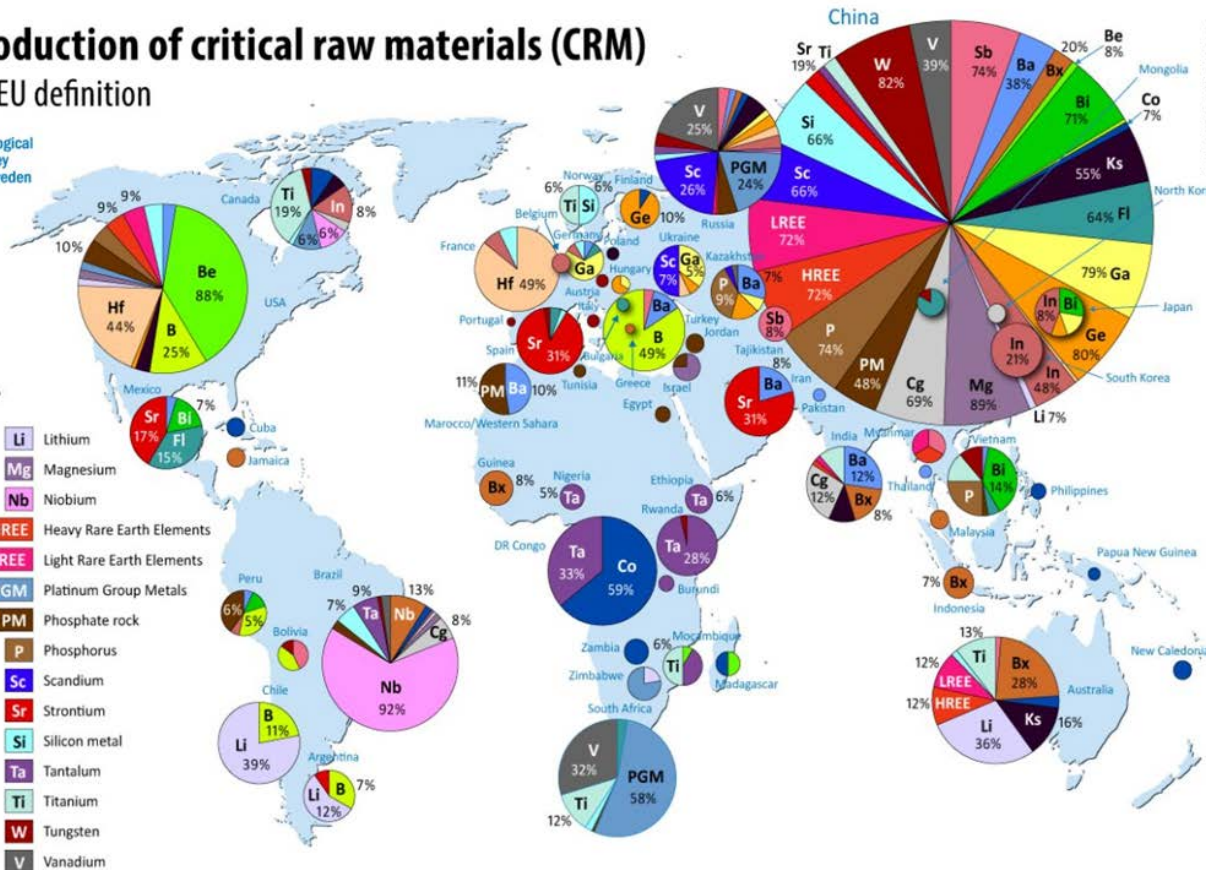
WHO?

Global production of critical raw materials (CRM) according to EU definition

SGU Geological Survey of Sweden

Critical raw materials included in the EU list *

Sb	Antimony	Li	Lithium
Bx	Bauxite	Mg	Magnesium
Ba	Baryte	Nb	Niobium
Be	Beryllium	HREE	Heavy Rare Earth Elements
Bi	Bismuth	LREE	Light Rare Earth Elements
B	Borate	PGM	Platinum Group Metals
Cg	Natural graphite	PM	Phosphate rock
Co	Cobalt	P	Phosphorus
Fl	Fluorspar	Sc	Scandium
Ga	Gallium	Sr	Strontium
Ge	Germanium	Si	Silicon metal
Hf	Hafnium	Ta	Tantalum
In	Indium	Ti	Titanium
Ks	Coking coal	W	Tungsten
		V	Vanadium



Access to
critical minerals
is strategic

China currently
controls most
REE production

Huge
opportunity for
African nations

Geopolitics of
resources will
only increase

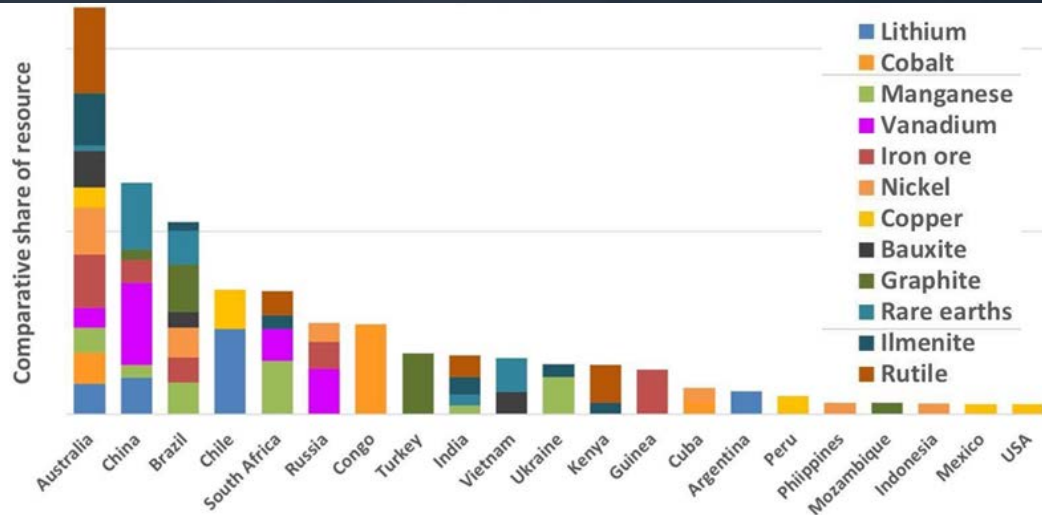
WHY?

WHAT?

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WHO?



Megasource countries for the supply of strategic new energy material resources

Country reported with 2.5% or more of global minerals of material in category

Data USGS Chart @FSS_Au @ProfRayWills 6Jun2018

Many countries have an opportunity to benefit from the 'Critical Metals Gold Rush'

Importance of Mining to Australia



Mining was worth \$455 Billion to the Australian economy in 2022-2023



Australia's mining sector



Contributes to around 13.4% of GDP



Makes up around two-thirds of Australia's total merchandise exports



Directly employs around 300,000 people

WHY?

WHAT?

WHERE?

HOW?

WHO?

Australia's Critical Mineral Opportunity



FUTURE CRITICAL

Meeting the minerals
investment challenge

Responsible
Australian
Mining



The battery minerals shortfall demands hundreds of new mines

More than 260 new lithium, cobalt, nickel and copper mines will be needed by 2030 if the world is to meet global demand for minerals-intensive electric vehicles and energy storage batteries.



140 Copper
mines



S&P Global

60 Nickel
mines



IEA

50 Lithium
mines



IEA

17 Cobalt
mines



IEA

Global mining investment required to reach net zero is staggering

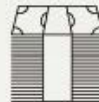
Australia has a once-in-a-century opportunity to generate sustained national prosperity and contribute in a substantial way to global clean energy supply chains, but only if it acts with urgency now.



2 times

Mining investment
Global investment will need to double by 2050 to meet demand for green tech.

S&P Global



us\$4 trillion

Investment to 2030
Global mining, refining and smelting investment required to achieve net zero.

McKinsey & Company



us\$160 billion

Over next 25 years
Annual global mining investment required to reach net zero by 2050.

S&P Global

Australia has the minerals, but is being outpaced by competitors

Australia has enviable reserves of future critical minerals but risks falling behind other highly competitive resource-rich countries with a strong political focus on the energy transition.



No.1

Global resources...
of recoverable nickel, zirconium (zirconium), rutile (titanium), uranium, gold and zinc.

Geoscience Australia



Top 5

Global resources...
of lithium, copper, bauxite, cobalt, tungsten, ilmenite, vanadium and manganese.

Geoscience Australia



80%

Under-explored
Opportunities for new mineral discoveries are vast with 80% of Australia under-explored.

Geoscience Australia

WHY?

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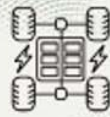
HOW?

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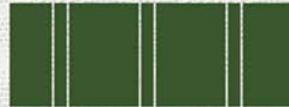
**100's of new mines
all around the
world are needed
to meet predicted
metal demand**

The battery minerals shortfall demands hundreds of new mines

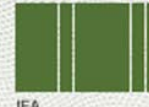
More than 260 new lithium, cobalt, nickel and copper mines will be needed by 2030 if the world is to meet global demand for minerals-intensive electric vehicles and energy storage batteries.



140 Copper
mines



60 Nickel
mines



50 Lithium
mines



17 Cobalt
mines



Average lag from discovery to mining is 10-15 yrs +

**Many of the largest mines in the world
have gone past peak production,
and some are closing**

Where will the new mines be?

How will you find them?

Mount Isa,
Cu mine
Qld, Australia



100's of new mines all around the world are needed to meet predicted metal demand

The battery minerals shortfall demands hundreds of new mines

More than 260 new lithium, cobalt, nickel and copper mines will be needed by 2030 if the world is to meet global demand for minerals-intensive electric vehicles and energy storage batteries.



140 Copper mines



S&P Global

60 Nickel mines



IEA

50 Lithium mines



IEA

17 Cobalt mines



IEA

Most of the mines of the future will be ore deposits that we haven't discovered yet!

Effective mineral exploration and training are crucial to meeting future mineral demand



WHY?

WHAT?

WHERE?

HOW?

WHO?

How will we Mine?

WHY?

WHAT?

WHERE?

HOW?

WHO?

Mining has always changed, and embraced technology



Australia's Oldest Mine:

30-40,000 years

Wilgie Mia (Thuwarri Thaa),

Wajarri Country, WA

Hematite ochre

South Australia's Oldest Mines:

Glen Osmond, 1845

Moonta Mines, 1860's

Cu, Au, Ag, Co

South Australia's Largest Mine:

Olympic Dam (IOCG)

Cu, Au (U, Ag)

10 Bt @ 0.57% Cu, 0.26 g/t Au, 1.0 g/t

Ag, 0.19 kg/t U₃O₈

WHY?

WHAT?

WHERE?

HOW?

WHO?

Mining is stuck with many stereotypes

Google

MINER

X

🔊

🌐

🔍

All

Images

News

Videos

Jobs

Forums

Web

More

Tools



Clipart



Drawing



Gold



49er



Pickaxe



Bitcoin



Transparent



Dnd



Game



Logo



Mighty



Modern



Pixel >



Wikipedia
Miner - Wikipedia



Getty Images
Miner Working At A...



iStock
34,700+ Miner Stock Photos, Pictur...



Wikipedia
History of coal min...



iStock
Best Miner Safety Avail...



Vecteezy
Miner PNGs for Free Download



Dreamstime.com
Flat Design Miner Stoc...



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Shutterstock
2,560 Coal Miner Drawi...



Mesothelioma Veterans Center
Mesothelioma & Miners | Asbestos ...



Getty Images
Mining, Coal miner, Prospecting



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34,700+ Miner Stock Photos, Pictur...



West Virginia Histor...
Coal Miner - West ...



WHY?

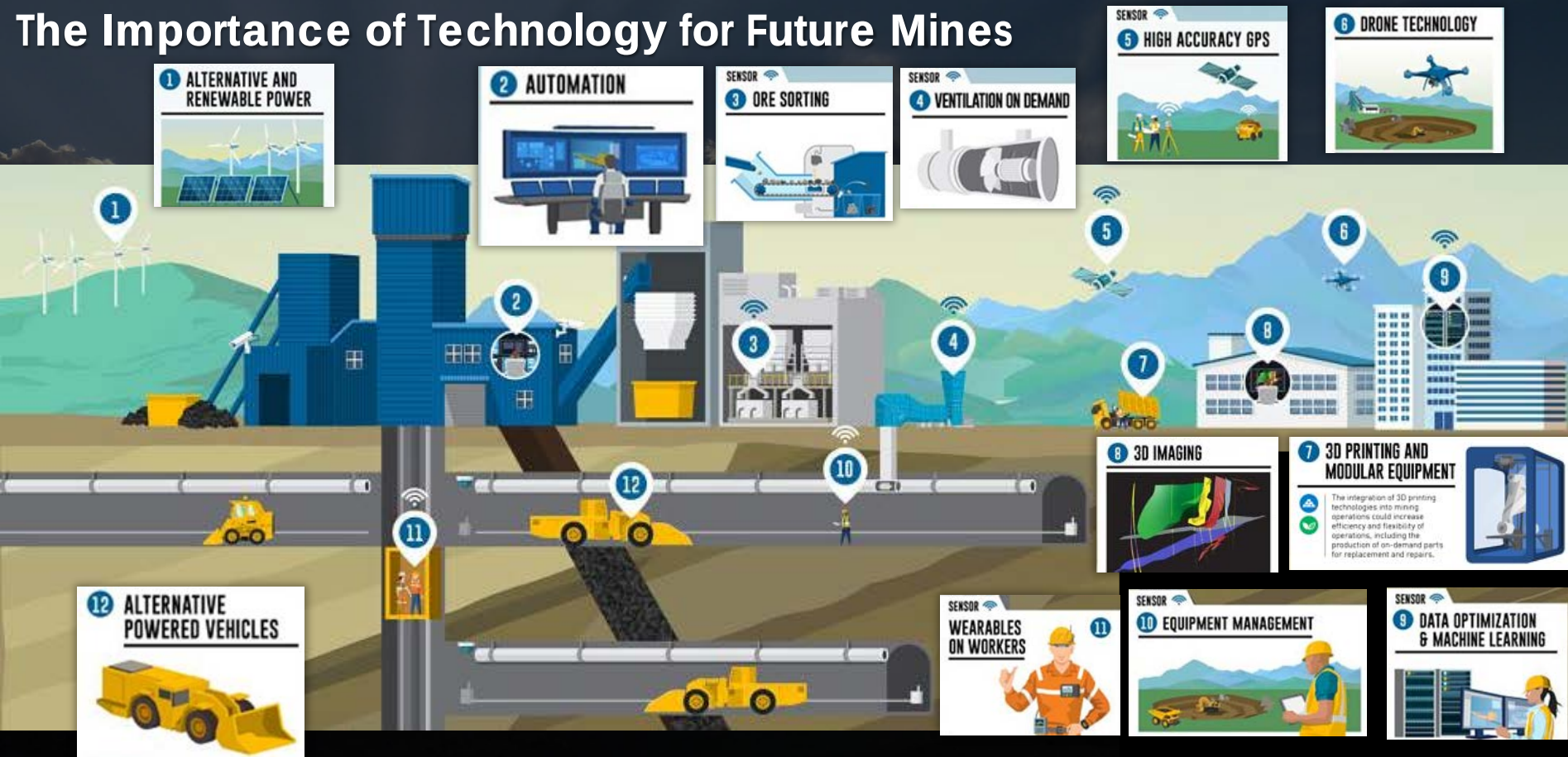
WHAT?

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The Importance of Technology for Future Mines



WHY?

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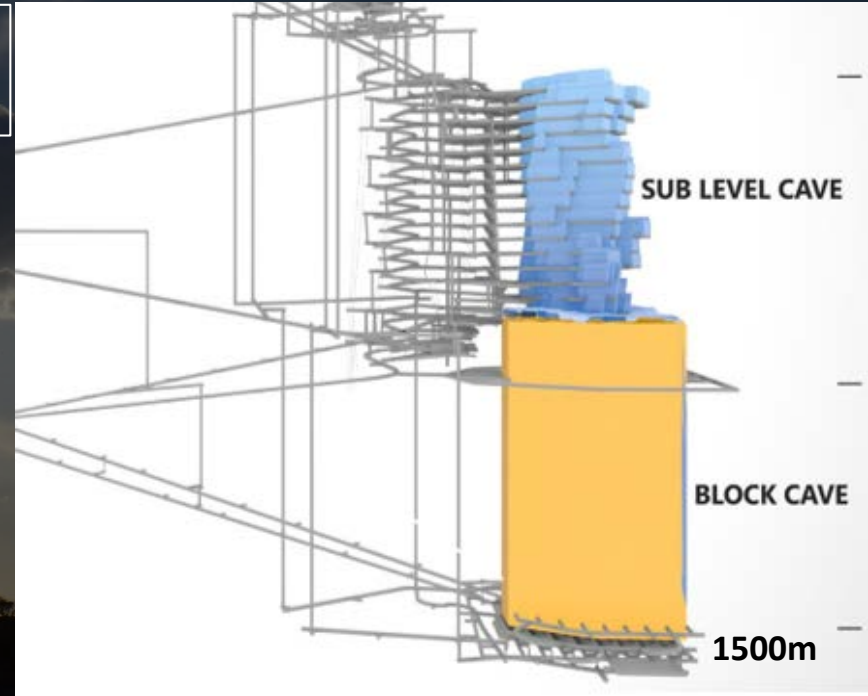
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The Importance of Technology for Future Mines: Mining styles

**Carrapateena Cu-Au deposit,
South Australia (950Mt @ 0.57% Cu, 0.25g/t Au)**



**Sub-level cave and Block cave operation (production level at 1,500m)
Long-mine life, most efficient underground mining technique**

WHY?

WHAT?

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The Importance of Technology for Future Mines: Mining styles

Kapunda, Cu-Au deposit, South Australia (47Mt @ 0.25% Cu for 119,000t Cu)

**In-Situ
Recovery
(ISR)**



WHY?

WHAT?

WHERE?

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WHO?

The Importance of Technology for Future Mines: Mining styles

Kapunda, Cu-Au deposit, South Australia (47Mt @ 0.25% Cu for 119,000t Cu)



- Discovered in 1842, mined from 1844-1879
- Important economically for South Australia
- Mined secondary Cu-oxides
- Site abandoned for >150 years



WHY?

WHAT?

WHERE?

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WHO?

The Importance of Technology for Future Mines: Mining styles

Kapunda, Cu-Au deposit, South Australia (47Mt @ 0.25% Cu for 119,000t Cu)



**Historic open pit
has become a
tourist attraction**

**Ground water is
very high in Cu**

**Site is currently using
In-Situ
Recovery (ISR)**

WHY?

WHAT?

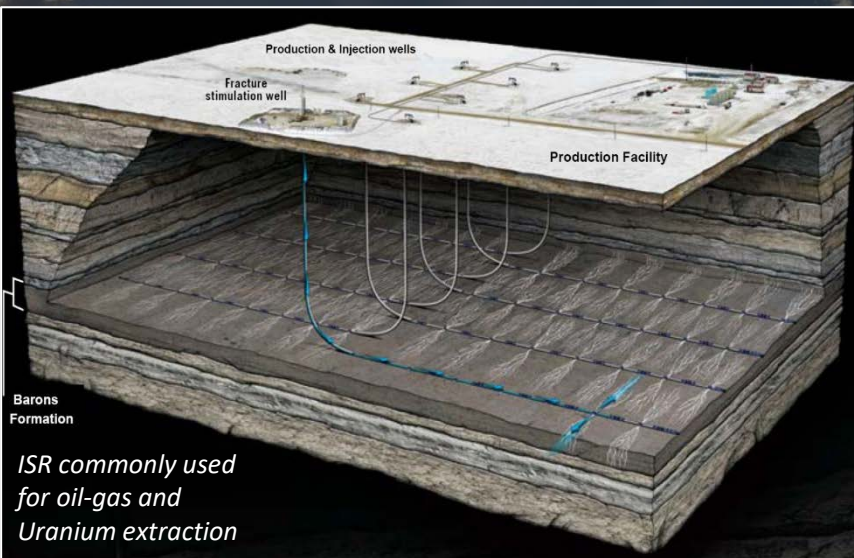
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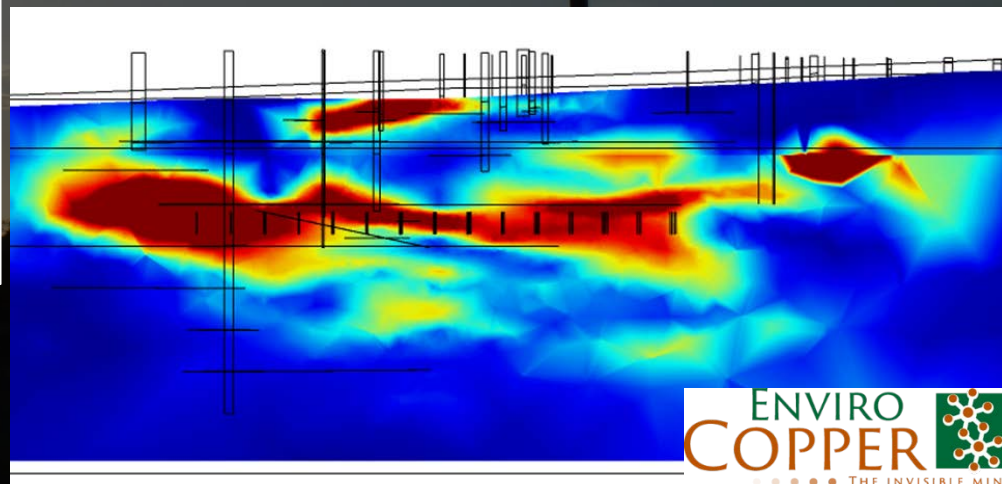
The Importance of Technology for Future Mines: Mining styles

Kapunda, Cu-Au deposit, South Australia (47Mt @ 0.25% Cu for 119,000t Cu)



ISR will access Cu-rich ground water

Fracture patterns and flow rates have been mapped and modeled



Careful monitoring and detailed geophysics surveys have been completed

WHY?

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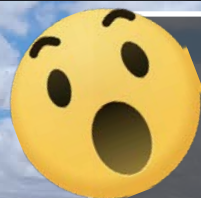
WHO?

The Importance of Technology for Future Mines: Mining styles

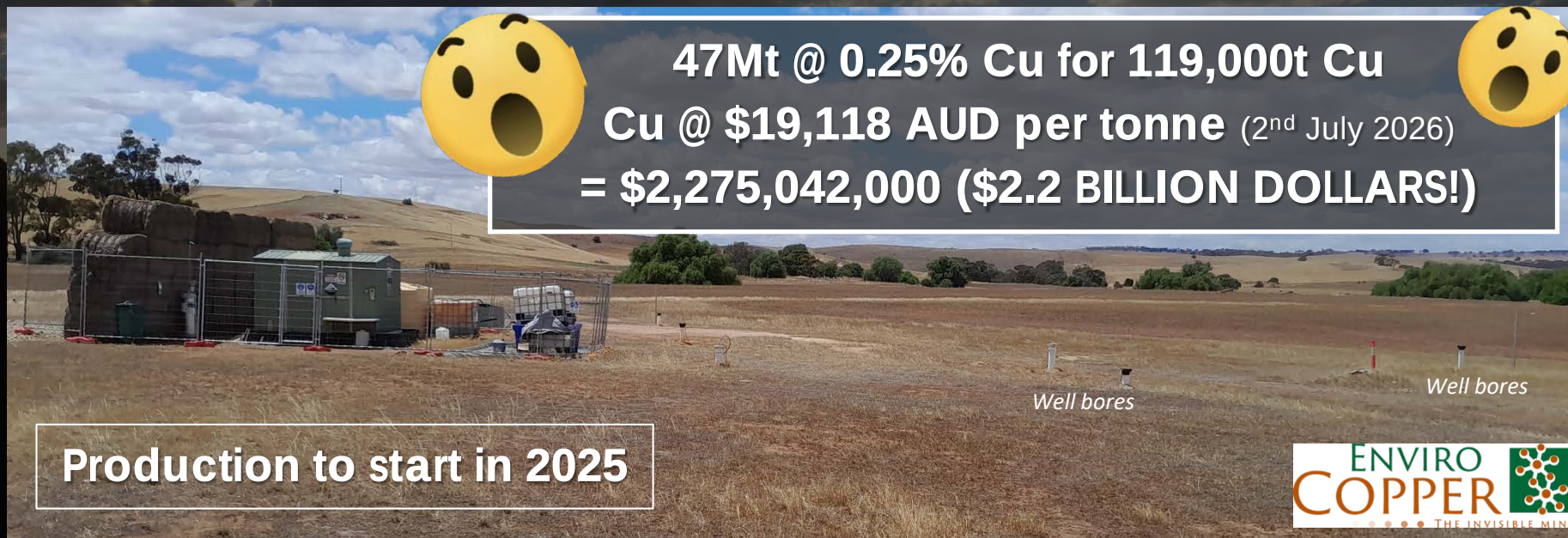
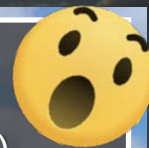
Kapunda, Cu-Au deposit, South Australia (47Mt @ 0.25% Cu for 119,000t Cu)

‘The invisible mine’

Technology has world-wide application



47Mt @ 0.25% Cu for 119,000t Cu
Cu @ \$19,118 AUD per tonne (2nd July 2026)
= \$2,275,042,000 (\$2.2 BILLION DOLLARS!)



Well bores

Well bores

Production to start in 2025

WHY?

WHAT?

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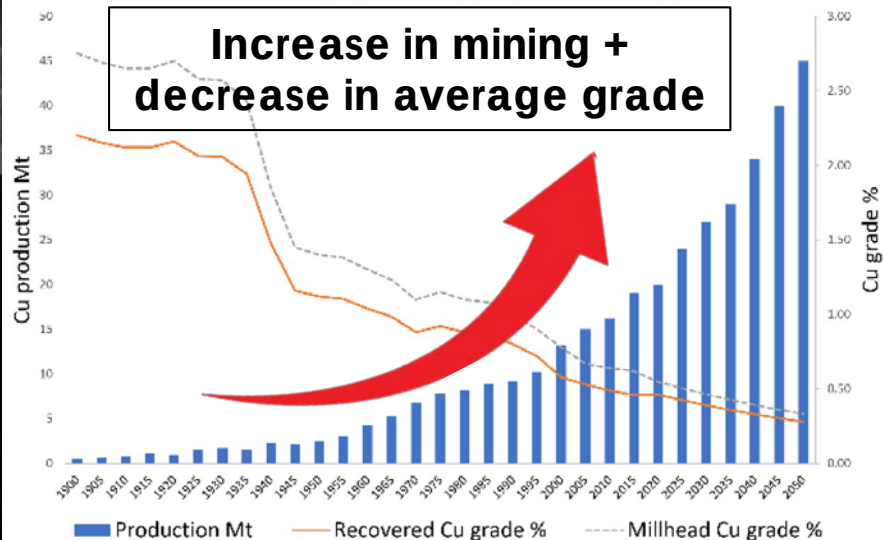
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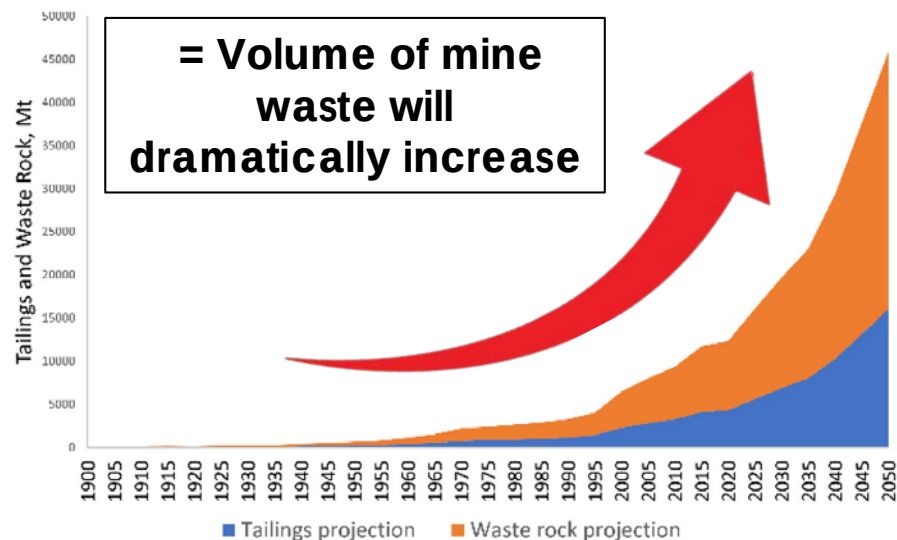
The Importance of Technology for Future Mines: WASTE

METAL RECOVERY FROM MINE WASTE IS SIGNIFICANT OPPORTUNITY

Historical and projected copper production by year



Cu tailings and waste rock, actual and projected



WHY?

WHAT?

WHERE?

HOW?

WHO?

The Importance of Technology for Future Mines: WASTE IS A BIG ISSUE

**METAL RECOVERY FROM MINE WASTE
IS ALSO SIGNIFICANT OPPORTUNITY**

**Future mines
must embrace
the CIRCULAR
ECONOMY**

**Growing importance to find
value in as many of the
products of mining as possible**



WHY?

WHAT?

WHERE?

HOW?

WHO?

The Importance of Technology for Future Mines: WASTE

**METAL RECOVERY FROM MINE WASTE
IS SIGNIFICANT OPPORTUNITY**



INNOVATION IS KEY



Au recovery



WHY?

WHAT?

WHERE?

HOW?

WHO?

The Importance of Technology for Future Mines: WASTE

METAL RECOVERY FROM MINE WASTE IS SIGNIFICANT OPPORTUNITY

Atlas of Australian Mine Waste



Australian Government
Geoscience Australia

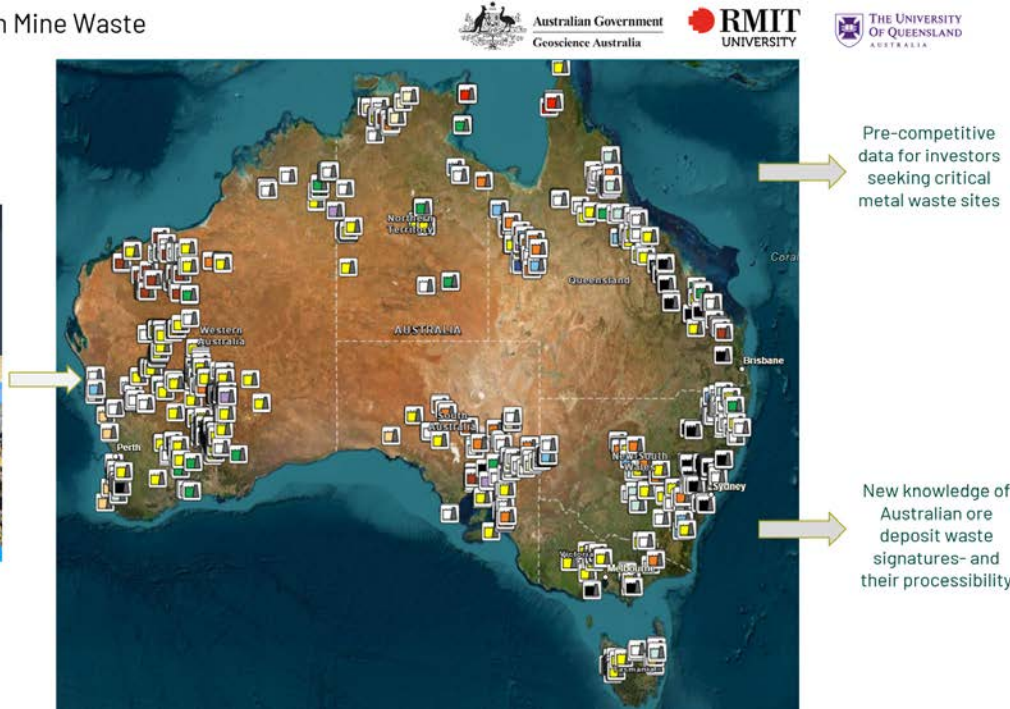


MIWATCH (SMI)

Stream 1

First pass investigation of mine waste

Rapid assessment of mine waste
identifying critical metal fertility using a
bespoke integrated chemical assay,
mineralogy and mineral chemistry
program



Australia is currently
investing in
generating an Atlas
of Mine Waste

Atlas lists quantity
and type of waste, as
well as metal content

WHY?

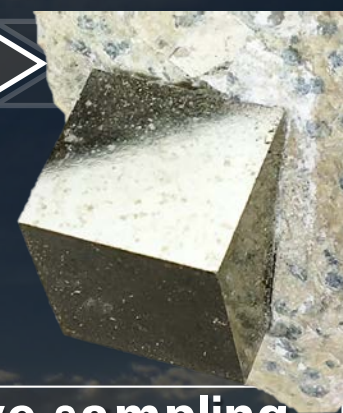
WHAT?

WHERE?

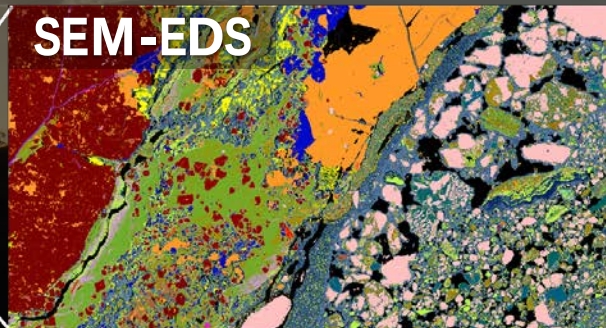
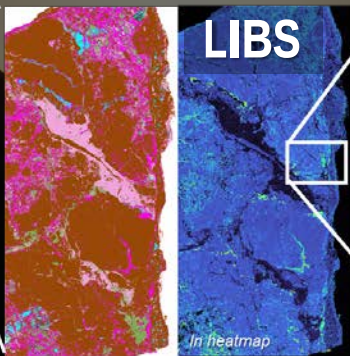
HOW?

The Importance of Technology for Future Mines: WASTE

**METAL RECOVERY FROM MINE WASTE
IS SIGNIFICANT OPPORTUNITY**



**Extensive sampling
taking place on
historic mine sites,
waste dumps and
tailings facilities**



**Multi-scale
characterisation is
also providing
metallurgical and
environmental data**

WHY?

WHAT?

WHERE?

HOW?

WHO?

The Importance of Technology for Future Mines: WASTE

**METAL RECOVERY FROM MINE WASTE
IS SIGNIFICANT OPPORTUNITY**

**BUT HOW DO WE RECOVER
THE METALS?**

**There is huge opportunity for
innovation in materials processing**

WHY?

WHAT?

WHERE?

HOW?

WHO?

The Importance of Technology for Future Mines: WASTE

**METAL RECOVERY FROM MINE WASTE
IS SIGNIFICANT OPPORTUNITY**

**Resin In Moist Mix (RIMM) method near
to large-scale trial in South Australia
~95% Cu recovery from waste material
in 1 hour treatment cycle**





WHY?

WHAT?

WHERE?

HOW?

WHO?

Who will Mine?

WHY?

WHAT?

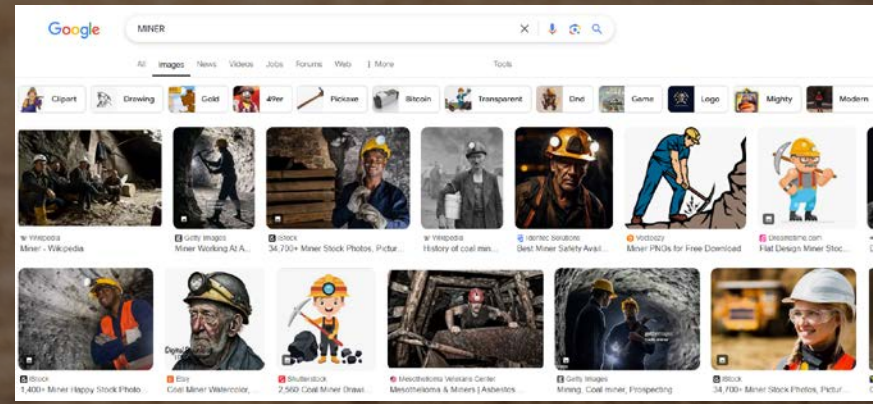
WHERE?

HOW?

WHO?



- How do we attract the next generation of talent into the exploration and mining industry?





The Industry and Education Landscape is Changing

Traditional Geoscience Education

UNCOVER
Challenge

Industry
5.0

UNCOVER
AUSTRALIA

Data Analytics
'Big Data'
Digital literacy

Disruptive Ideas

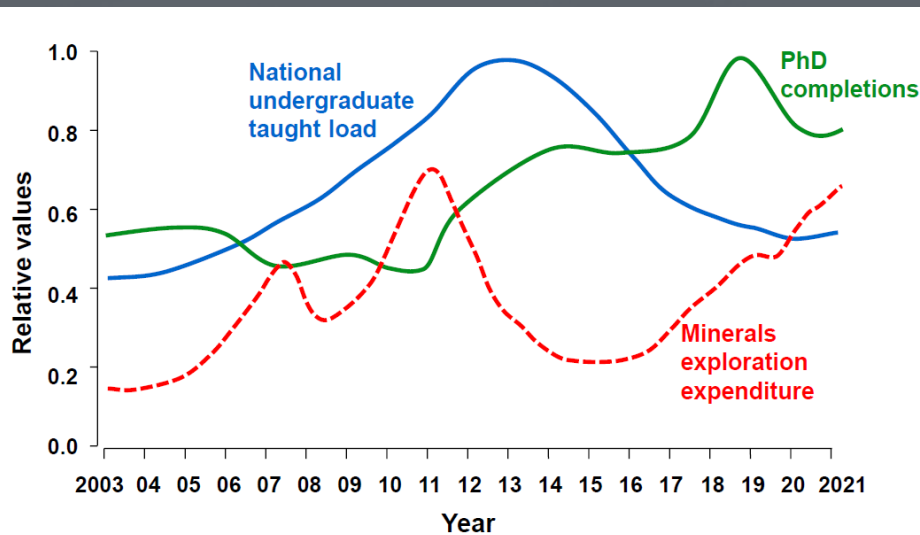
New Technologies

Community Acceptance

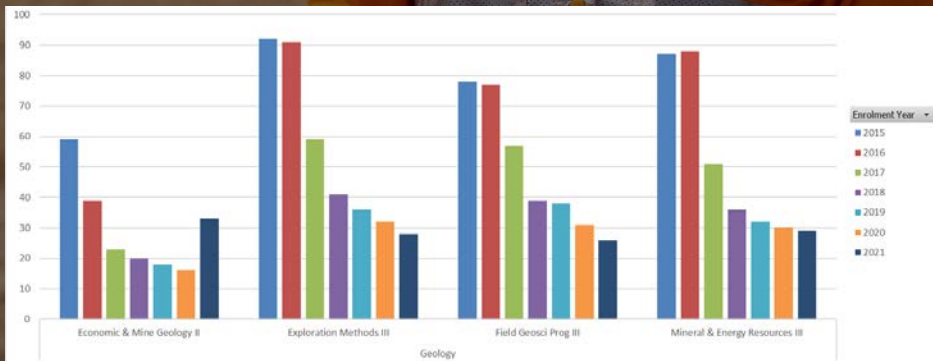
Partnerships with
Traditional
Owners

Diversity
of People

Retaining Talent



2021 Australian Geoscience Tertiary Education Profile
Report to the Australian Geoscience Council. www.agc.org.au/reports.



UnSelected 2nd+3rd yr Geoscience enrolments at University of Adelaide 2015-2021

- 17 Universities in Australia offer geoscience degrees (2 lost since 2022)
(Only 2 offer geophysics in 2024)

**GEOSCIENCE AND
STEM TEACHING IN IS
IN TROUBLE!**

***(Many universities are
in trouble!)***

- Not just geoscience
(Mining Engineering has known
for years... + Chemical Eng)

WHY?

WHAT?

WHERE?

HOW?

WHO?

Where are the geoscience/STEM students going to come from?

- Kids don't know about geoscience!
- There is a huge disconnect between 'stuff' and 'mining'

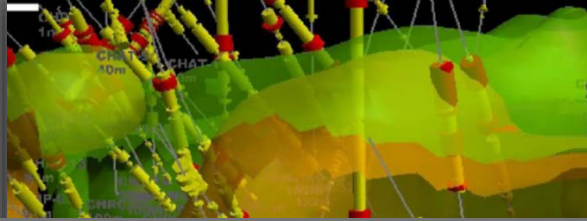
Lack of knowledge about careers

Mining lacks personal relevance

Few students hard set on single career choice

- 
- Just 1% of young Australians are interested in mining careers
 - 73% believe it does more harm than good
 - 40% of STEM students lack a clear understanding of the modern industry
 - 70% globally were not considering it

What skills will geoscientists of the future require?



They need to
be good
geoscientists!



“
Mining companies are increasing their
graduate intake. But reducing the intake
of the traditional disciplines.”

Brendan Howard
RIOTINTO



- How can we best prepare them for the industry?





NEXUS
National Exploration
Undercover School

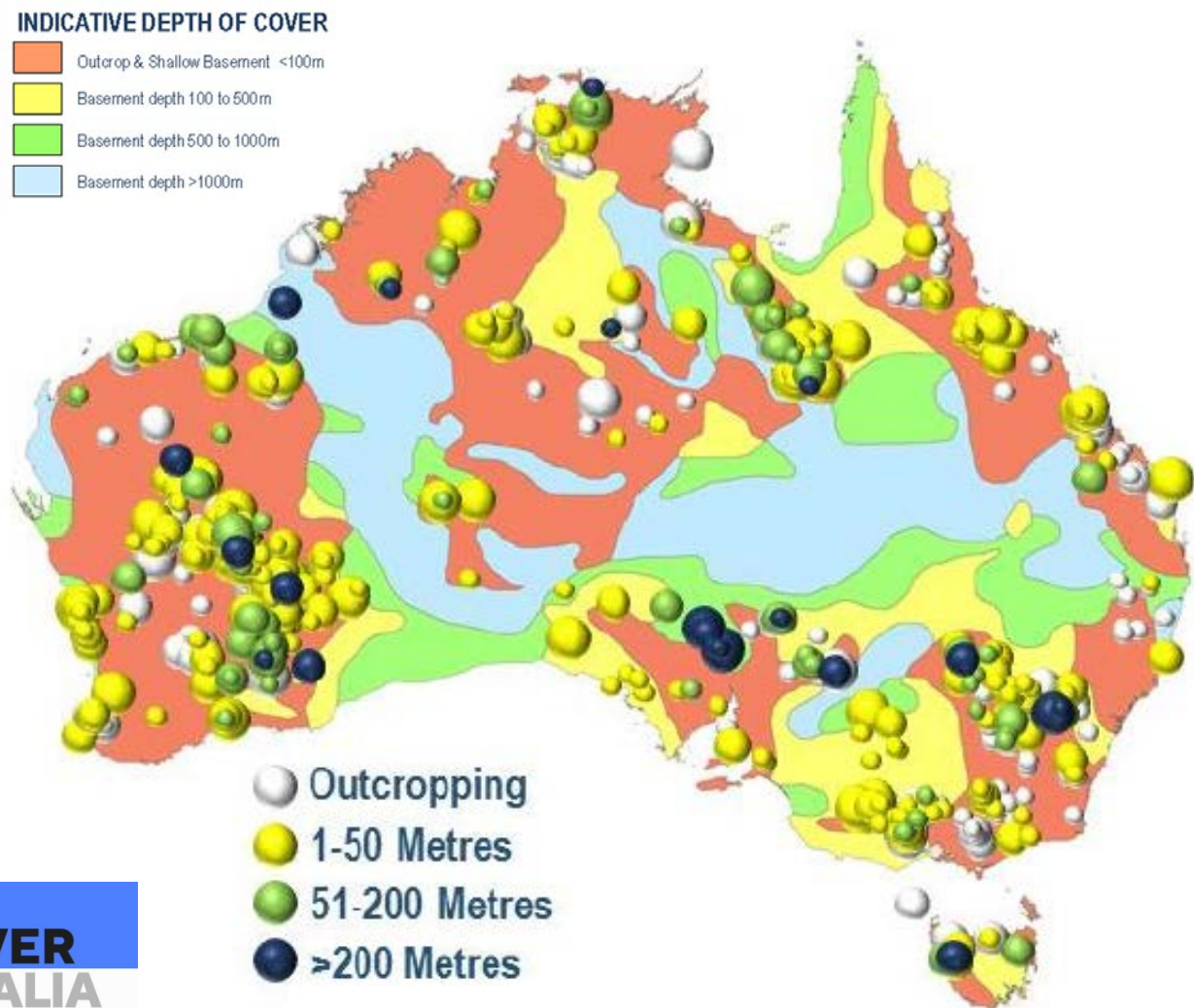


Minerals
Council of
Australia

- Founded in 2016, NEXUS is a collaboration of Universities, Government and Industry partners to deliver a world-class program of training.
- Students from any University across Australia can apply to be part of the programs; intention is to have a group of passionate and engaged students.

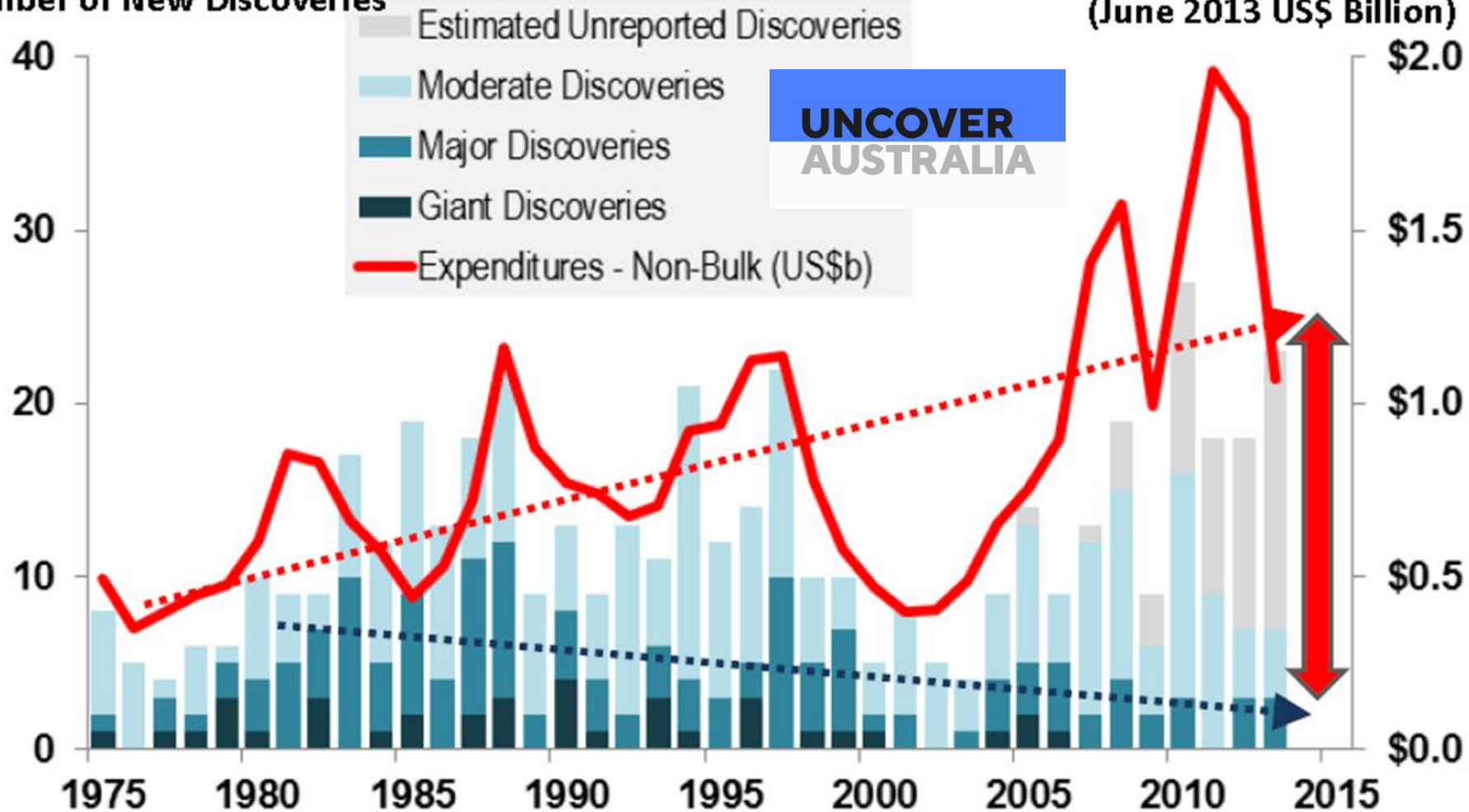
Exploration Under Post-Mineralisation Cover

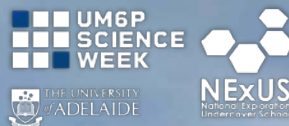
- Almost all the major mineral discoveries in Australia were in places with outcropping host geology: <50% of the continent.
- **New discoveries MUST be found under cover (~75% of continent)**



Total Expenditures
(June 2013 US\$ Billion)

Number of New Discoveries



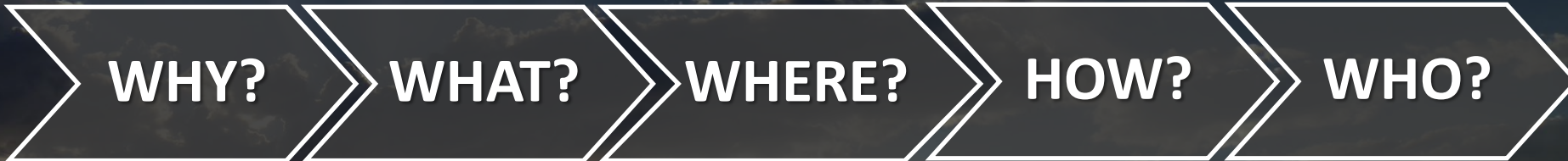


2024 In-kind supporters

2024 Financial Sponsors



2024
NEXUS



WHY?

WHAT?

WHERE?

HOW?

WHO?

We urgently need to inspire and upskill the next generation of exploration and mining professionals to meet the growing demand for critical metals



WHY?

WHAT?

WHERE?

HOW?

WHO?



**The mine of the future will look like
WE want it to**



Thank You

WHY?

WHAT?

WHERE?

HOW?

WHO?

The Mine of the Future