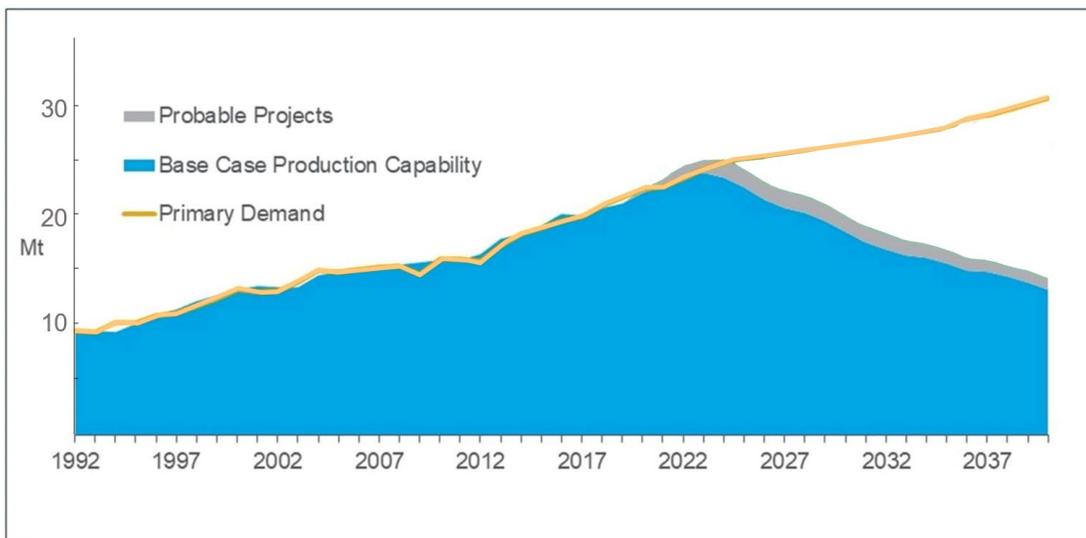
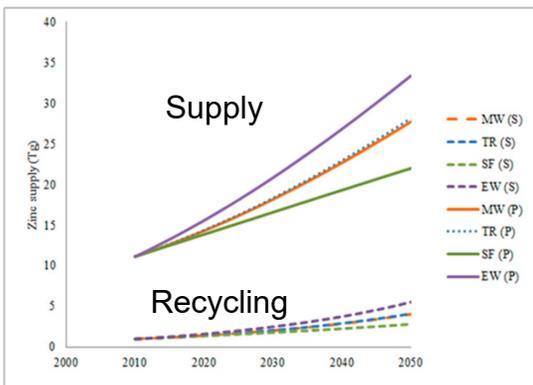


Global copper production and primary demand



Source: Wood Mackenzie

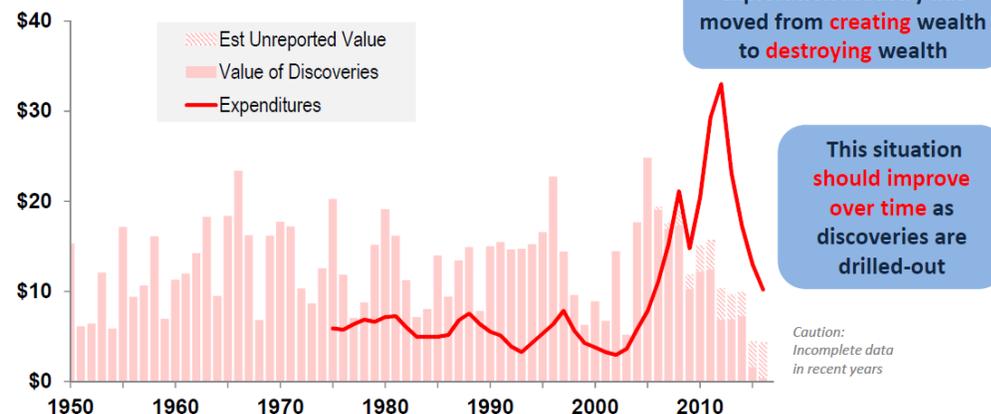


Elshkaki et al, 2018

Estimated value of discoveries versus expenditures

Mineral discoveries in the World : All Commodities : 1950-2016

2016 US\$ billion



Over the last decade the exploration industry has moved from **creating** wealth to **destroying** wealth

This situation **should improve** over time as discoveries are drilled-out

Caution: Incomplete data in recent years

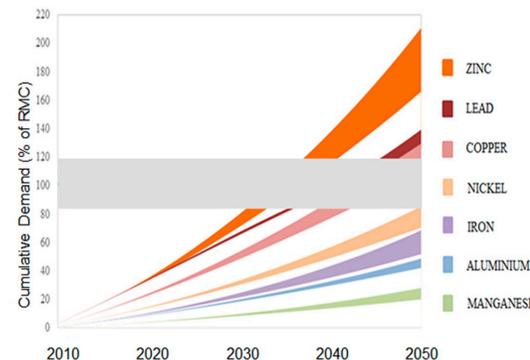
Caution: Values are indicative / approximate-only
No World exploration expenditure data prior to 1975
2007-2016 Cu: Spent \$35bn; Value \$17bn
(Dan Wood, 2019)

Source: MinEx Consulting © March 2017

MinEx Consulting

Strategic advice on mineral economics & exploration

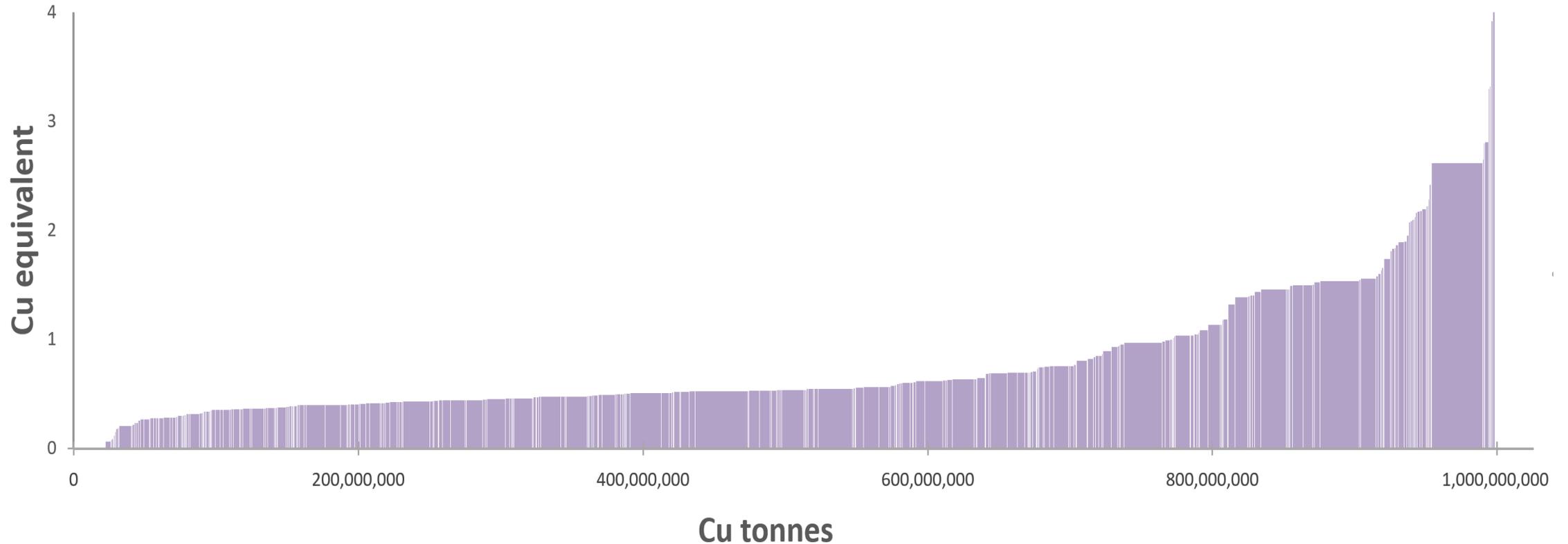
35



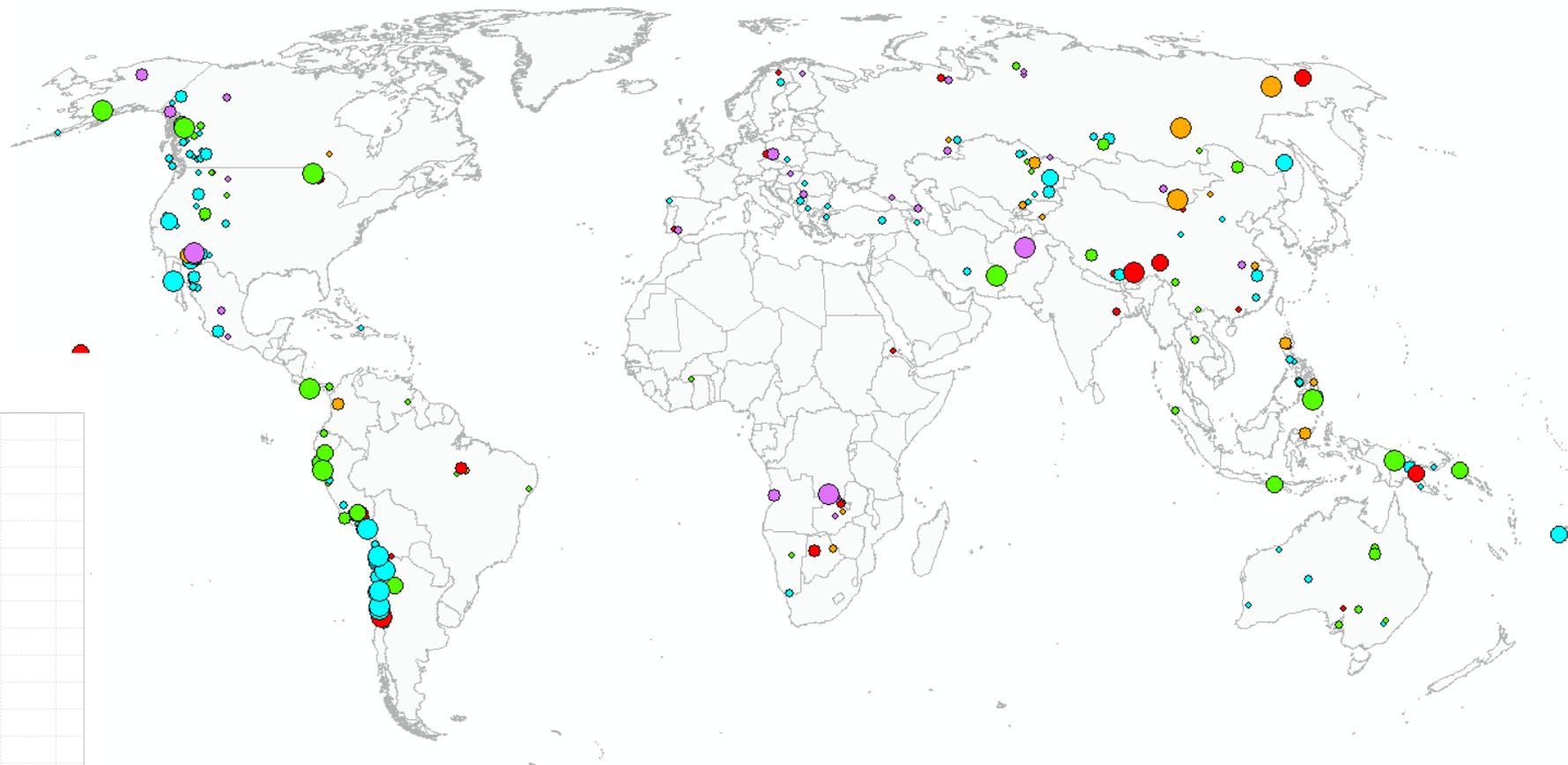
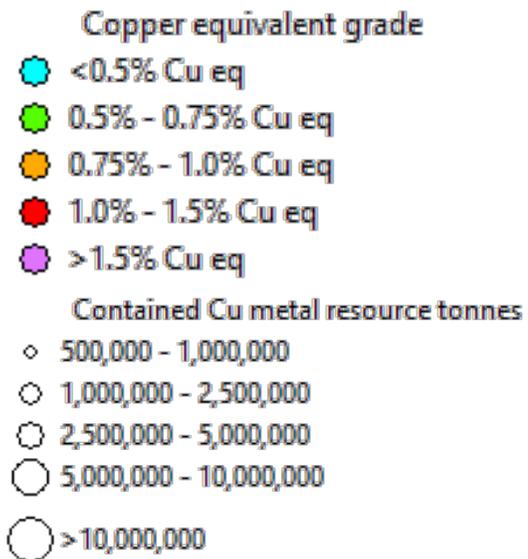
Elshkaki et al, 2018

Contained copper in undeveloped Mineral Resources

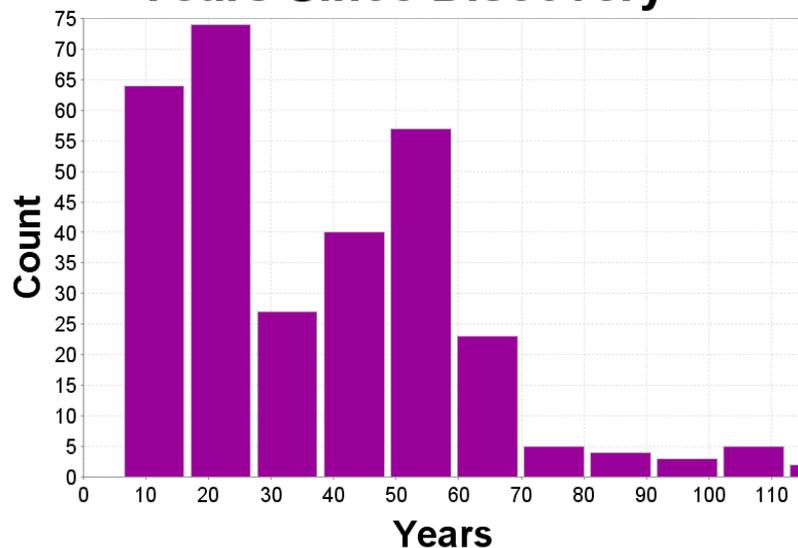
> 1 billion tonnes of contained copper metal



Distribution of undeveloped copper deposits

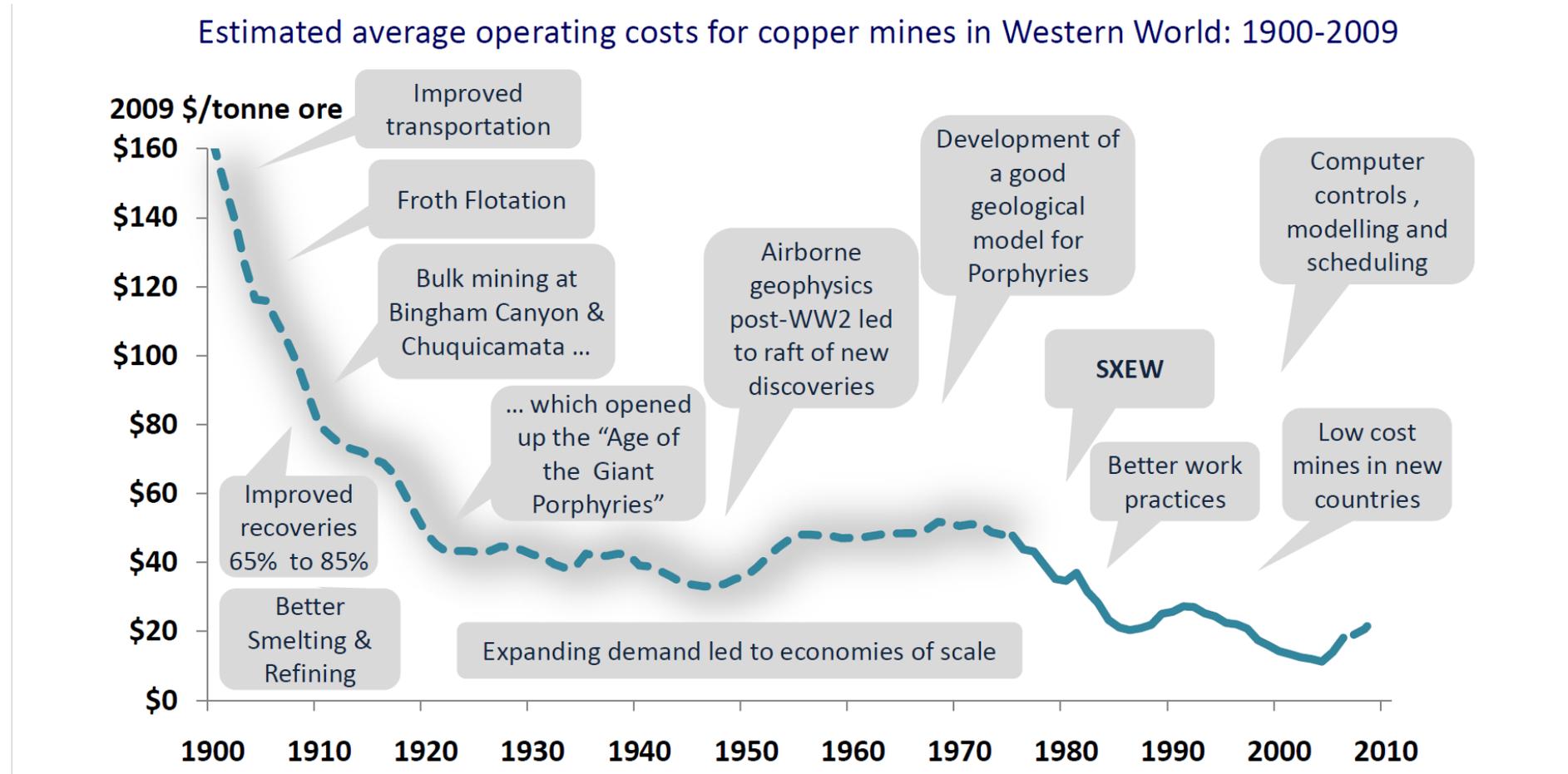


Years Since Discovery



Source: S&P Market Intelligence

Technology, cost reduction, price increases solved challenges in past...



Source: Minex Consulting

Can continued cost reduction alone unlock complex copper orebodies?

BRISBANE MINING CLUB



AT A GLANCE

Speaker

Charlie Sartain
Chairman - Sustainable Minerals
Institute at The University of Qld

Date

Thursday 17th October 2019

Time

12.00pm to 2.00pm

Venue

The Tattersall's Club
215 Queen Street, Cnr Queen
and Edward, entrance from the
Tattersall's Shopping Arcade.

Our Gold Sponsors



CHARLIE SARTAIN



Sustainable Minerals Institute at
The University of Qld

Charlie Sartain graduated with an honours degree in mining engineering from the University of Melbourne and worked as a professional for more than 30 years in the mining industry, initially in engineering roles at

roles in listed companies and not-for-profit organisations. He is currently a non-executive Director of ASX-listed companies ALS Limited and Oz Minerals Limited, and a non-executive Director of the world's largest gold

The Conundrum of the Undeveloped Complex Orebodies

Charlie Sartain

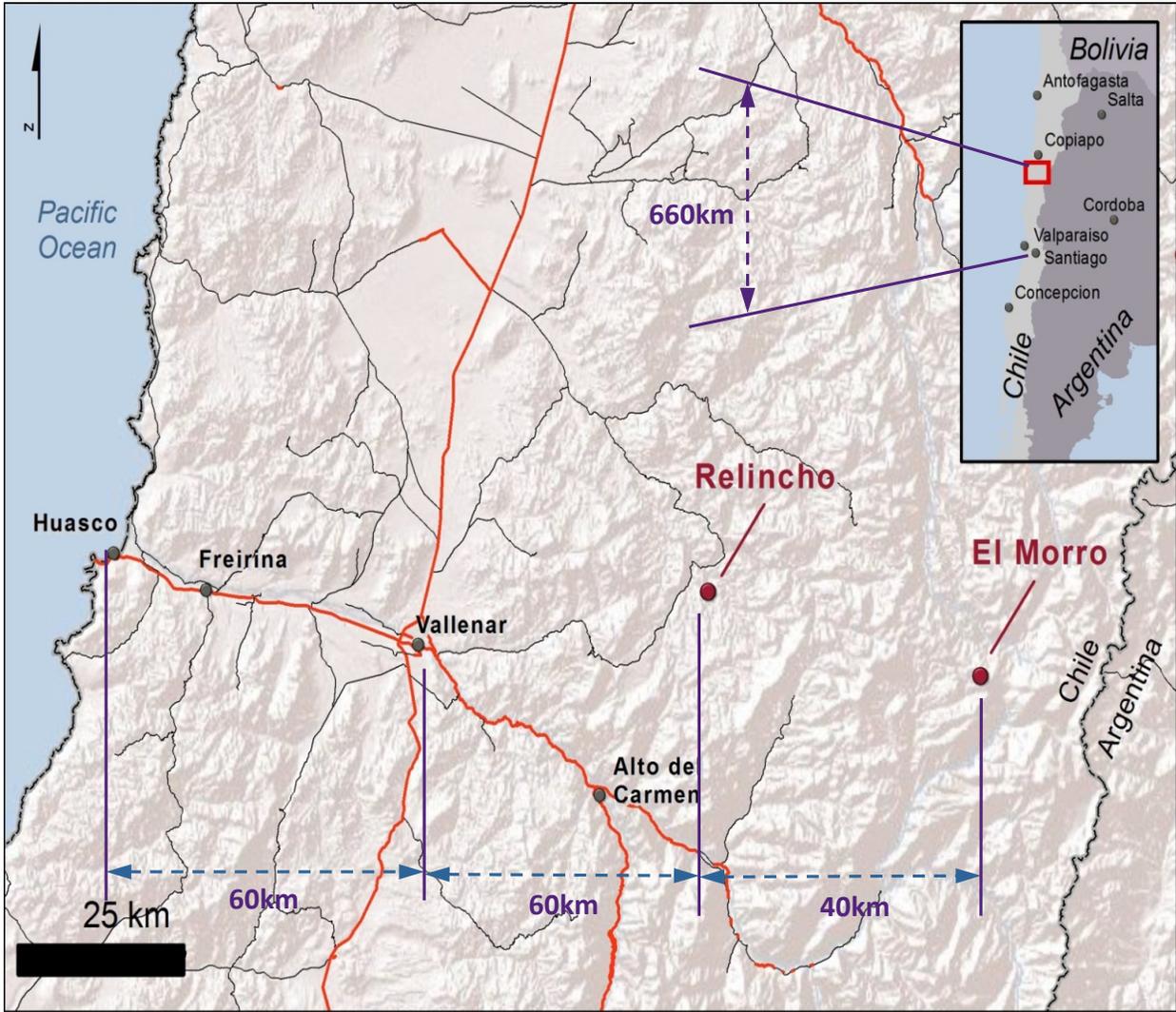


Nueva Unión

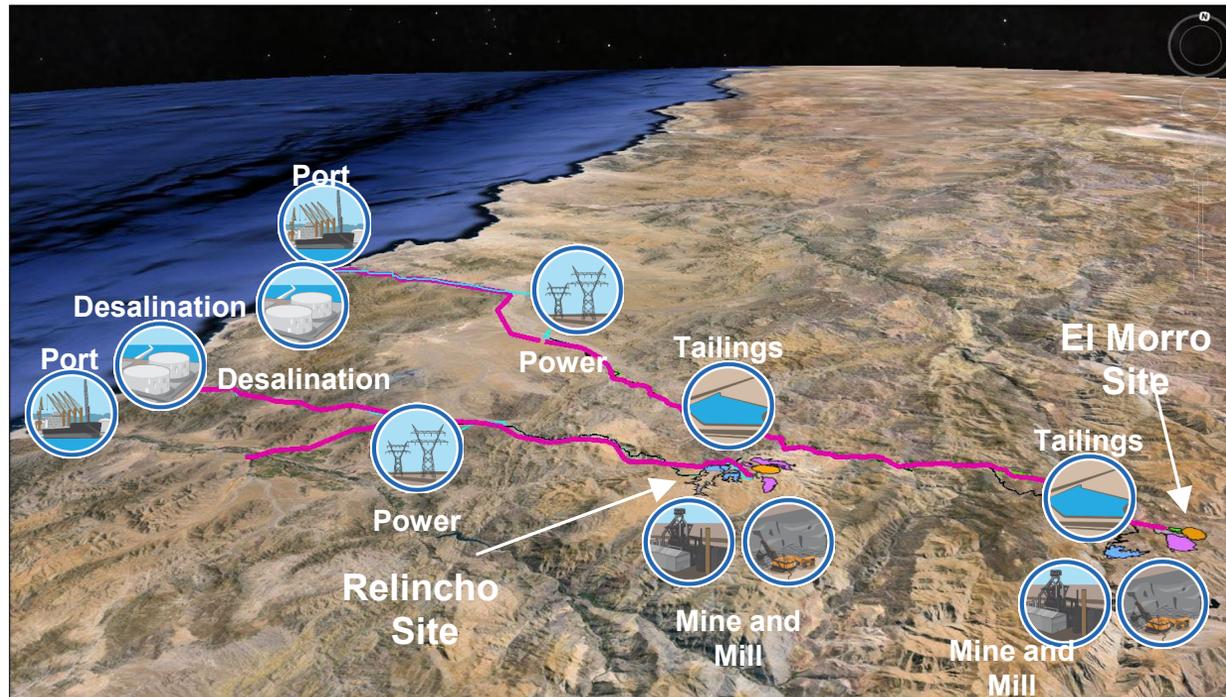
An aerial photograph of a small town, Nueva Unión, nestled in a valley. The town is illuminated by warm, golden lights, likely from street lamps or building lights, contrasting with the dim, twilight sky. The surrounding landscape is rugged and mountainous, with sparse vegetation and rocky terrain. The mountains in the background are bathed in the soft, low-angle light of the setting or rising sun, creating a dramatic and atmospheric scene. The overall color palette is dominated by earthy tones of brown, tan, and grey, punctuated by the vibrant yellows and oranges of the town's lights.

Nueva Unión – Project risk management approach

Project Name	Nueva Union
Copper (eq)	0.48
Cu tonnes	13,908,255
Grade	
Water	
Tailings	
Variability	
Permitting	
Legal	
Local Community	
Land Pressure	
Poverty	
Arsenic	
Biodiversity	
Infrastructure	



Integrating two projects into one

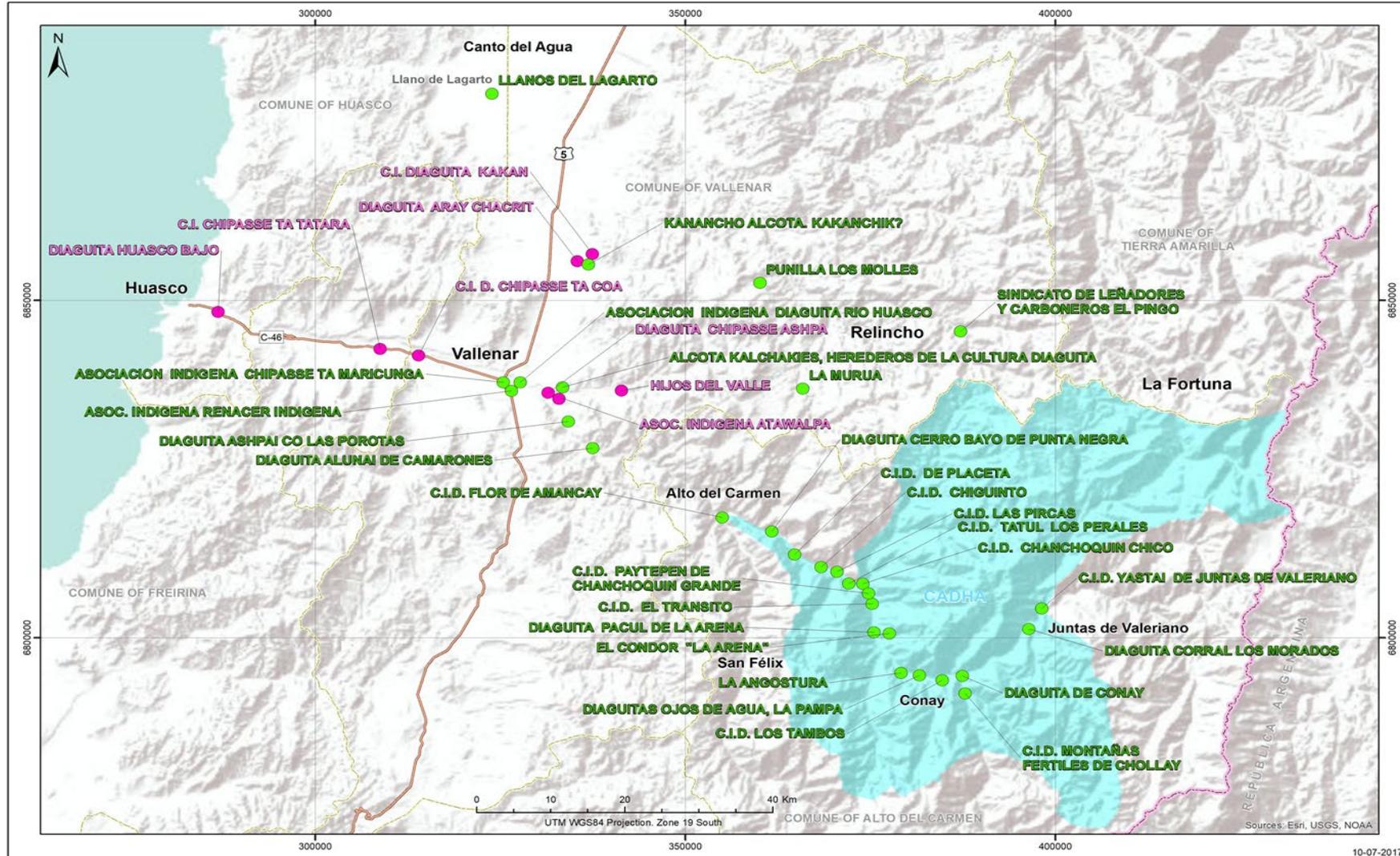


Proposed infrastructure to support the separate Relincho and El Morro projects



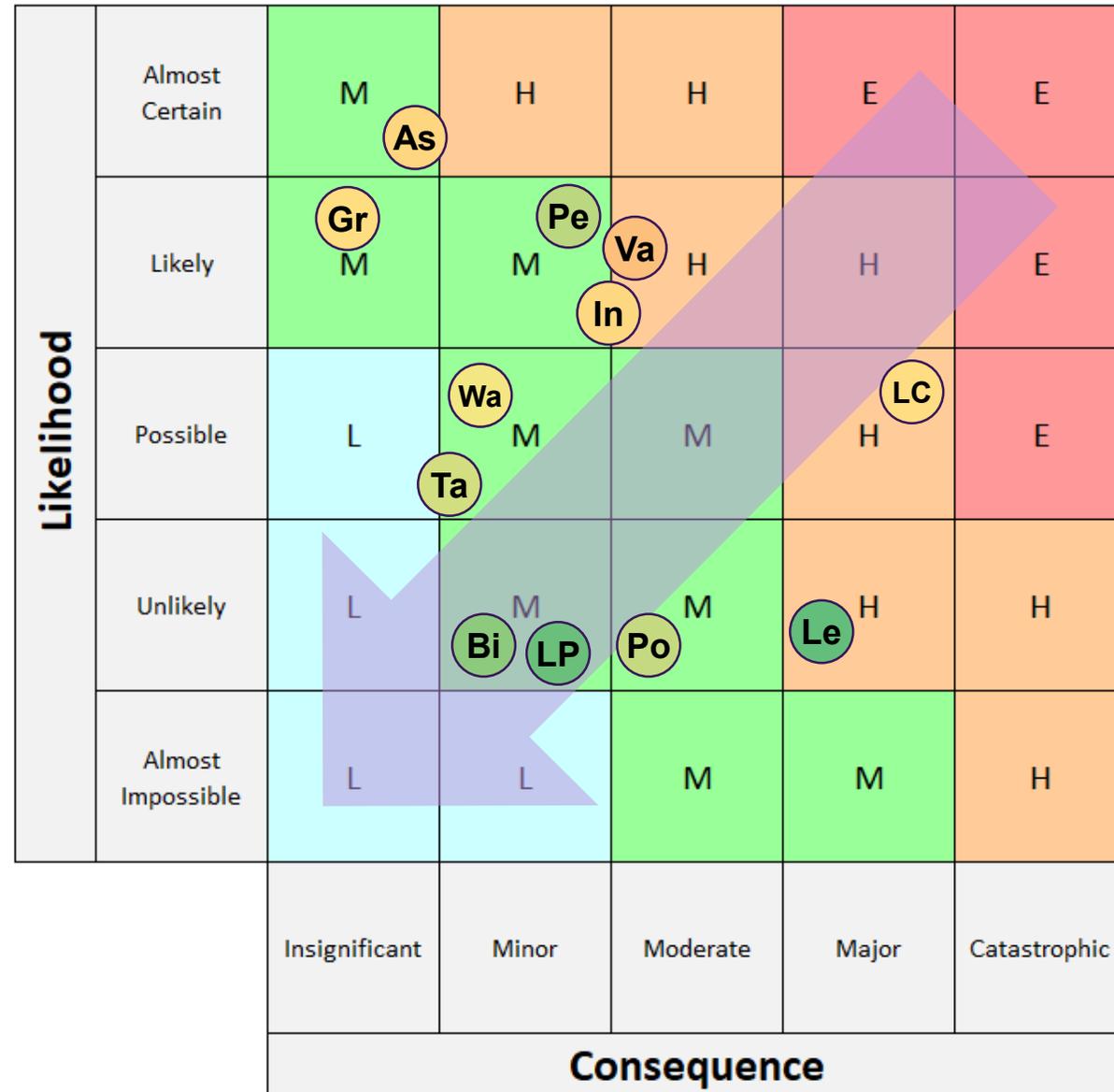
Proposed infrastructure to support the combined NuevaUnión project

Nueva Unión - Community Relations: The Diaguita



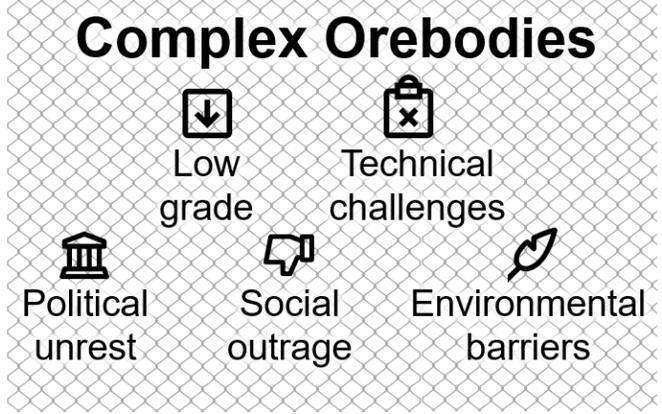
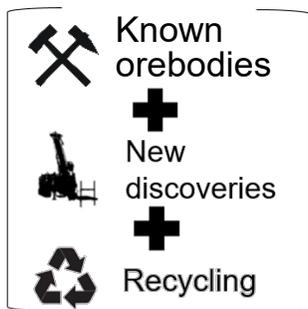
Nueva Unión - Risk Matrix Overview

Project Name	Nueva Unión
Copper (eq)	0.48
Cu tonnes	13,908,255
Grade	 Gr
Water	 Wa
Tailings	 Ta
Variability	 Va
Permitting	 Pe
Legal	 Le
Local Community	 LC
Land Pressure	 LP
Poverty	 Po
Arsenic	 As
Biodiversity	 Bi
Infrastructure	 In



Complex Orebodies

SUPPLY OF THE FUTURE



- Better, fairer social relationship
- Reduced environmental and social footprint
- Technical Innovation

KEY QUESTIONS



Social Footprints and Data



Low Footprint Processing



Variability and Flexibility



Energy and Efficiency

PROJECT EXAMPLES

- Community and Social Performance
- LSM-ASM
- ESG analysis of Complex Orebodies

- Alternative processing
- Water efficiency
- Waste minimisation
- Deleterious elements

- Ore Deposit Knowledge
- Performance prediction
- Flexible processing
- Holistic evaluation

- Novel comminution and separation
- Transformative processing

WHO?

	Sustainable Minerals Institute	School of Mechanical and Mining Engineering	School of Chemical Engineering	School of Earth and Environmental Sciences
	Social Science	School of IT and Electrical Engineering	UQ Business School	School of Civil Engineering

and many others...

Theme 1 - Understanding Complex Orebodies

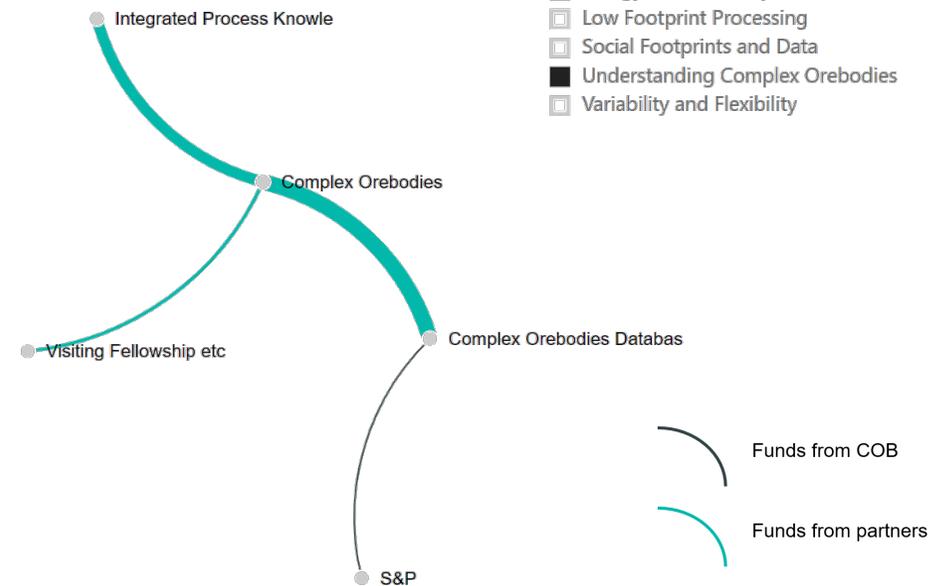
Top 40 Copper Projects and risks

- Category
- Administration
 - Energy and Efficiency
 - Low Footprint Processing
 - Social Footprints and Data
 - Understanding Complex Orebodies
 - Variability and Flexibility

530mT Cu metal

Project Name	Cu eq	Cu tonnes	Grade	Water	Tailings	Variability	Permitting	Legal	Local Community	Land Pressure	Poverty	Arsenic	Biodiversity	Infrastructure
Pebble	0.53	36,881,566												
Kamoa-Kakula	2.62	35,877,000												
Resolution	1.54	27,465,100												
Udachi	0.97	26,700,000												
Rahu Dig	0.56	24,351,000												
La Granja	0.51	22,655,000												
Toija Cluster	0.43	19,984,000												
Los Blancos Underground	1.46	17,520,000												
KSM	0.54	15,814,485												
Tampakan	0.64	15,255,000												
El Fierbo	0.48	15,100,000												
Nuna/Union	0.48	13,908,255												
Los Azules	0.49	13,380,564												
Quellavaco	0.46	13,054,000												
Taca Taca	0.46	12,934,000												
Frieda River	0.62	12,590,000												
Cerro Colorado	0.69	11,962,000												
Oroya	1.00	11,900,000												
Agnan	1.56	10,995,000												
Twin Metals	0.56	10,886,208												
El Alico	0.40	10,792,000												
Los Helados	0.45	10,674,953												
Lookout Hill	0.76	10,408,576												
Qitong	1.04	10,360,000												
Los Volcanes	0.50	9,441,000												
Wafi-Golpu	1.39	8,784,000												
Santa	0.21	8,699,000												
Clarion Clipperton Zone	1.14	8,641,000												
Altar	0.37	8,408,010												
Lirioyay	1.50	7,500,000												
Namosi	0.42	7,471,000												
Agua Rica	0.53	7,419,404												
West Wall	0.53	7,379,000												
Los Blancos Sur	0.81	7,290,000												
Rio Blanco	0.57	7,107,000												
Cerro Negro	0.70	6,960,000												
Panantz	0.62	6,596,000												
Ann Mason	0.32	6,535,829												
Yulong	1.50	6,500,000												
Santa Cruz	0.90	6,023,520												

High Risk
Moderate Risk
Low Risk



Journal of Cleaner Production

Available online 20 February 2019

In Press, Accepted Manuscript



Re-thinking complex orebodies: Consequences for the future world supply of copper

R.K. Valenta ^a, D. Kemp ^b, J.R. Owen ^b, G.D. Corder ^c, É. Lèbre ^b

Show more

<https://doi.org/10.1016/j.jclepro.2019.02.146>

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9:30 - 9:50	Complex Orebodies Database	CSRM-CMLR-BRC-UQBS-SEES	Éléonore Lèbre
9:50 - 10:10	System Dynamics applied to Complex Orebodies	JKMRC-UQBS-CSRM-CCSG	Gordon Forbes
15:00 - 15:20	Mine Closure Database	CSRM-MLC	John Owen



Cite This: Environ. Sci. Technol. XXXX, XXX, XXX-XXX

Policy Analysis
pubs.aocs.org/est

Source Risks As Constraints to Future Metal Supply

Éléonore Lèbre [✉]

Postdoctoral Research Fellow, Centre for Social Responsibility in Mining, Sustainable Minerals Institute, The University of Queensland, Queensland 4072, Australia

John R. Owen

School of Earth and Environmental Sciences

UQ Business School

S&P Global

Theme 2 - Social Footprints and data

- Social data methodology and insight
- Holistic evaluation – surface and sub-surface
- Procedural fairness
 - Better integration and analysis of the spatial and temporal data layers relating to the social impacts of mining
 - Social data and community involvement at the forefront of project planning and operation

RioTinto

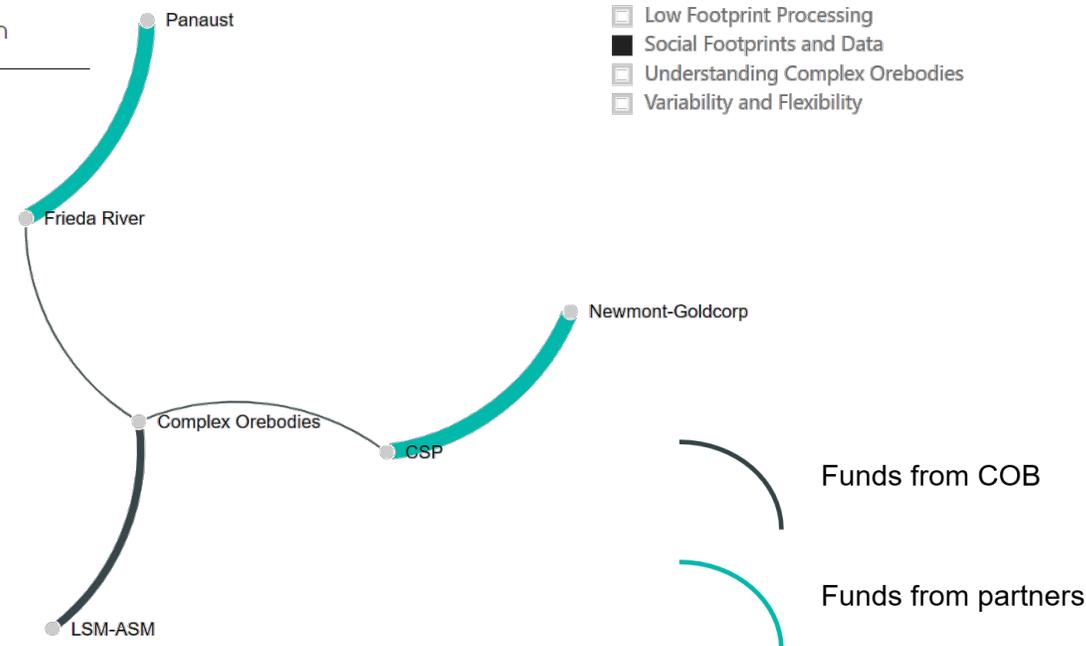


14:20 - 14:40	Community and Social Performance	CSRSM	Deanna Kemp
14:40 - 15:00	ASM at the Frieda River project	CSRSM-SMI	Nick Bainton

- Category
- ☐ Administration
 - ☐ Energy and Efficiency
 - ☐ Low Footprint Processing
 - Social Footprints and Data
 - ☐ Understanding Complex Orebodies
 - ☐ Variability and Flexibility

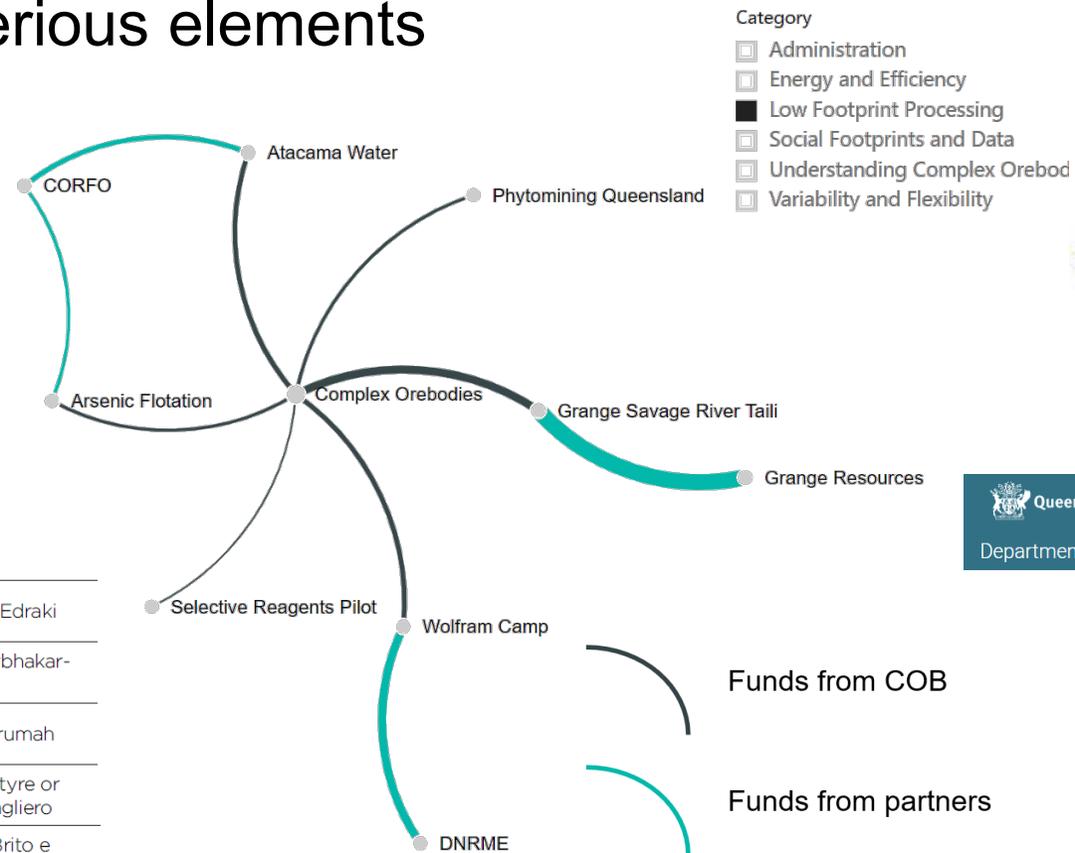


Strategic review of Communities and Social Performance (CSP) capacity.



Theme 3 - Low footprint processing

- New technologies and strategies to surmount environmental barriers through
 - alternative processing
 - water efficiency
 - minimisation of waste and deleterious elements
 - Dry/benign tailings
 - In-situ mining



Queensland Government
Department of **Natural Resources, Mines and Energy**

School of Chemical Engineering

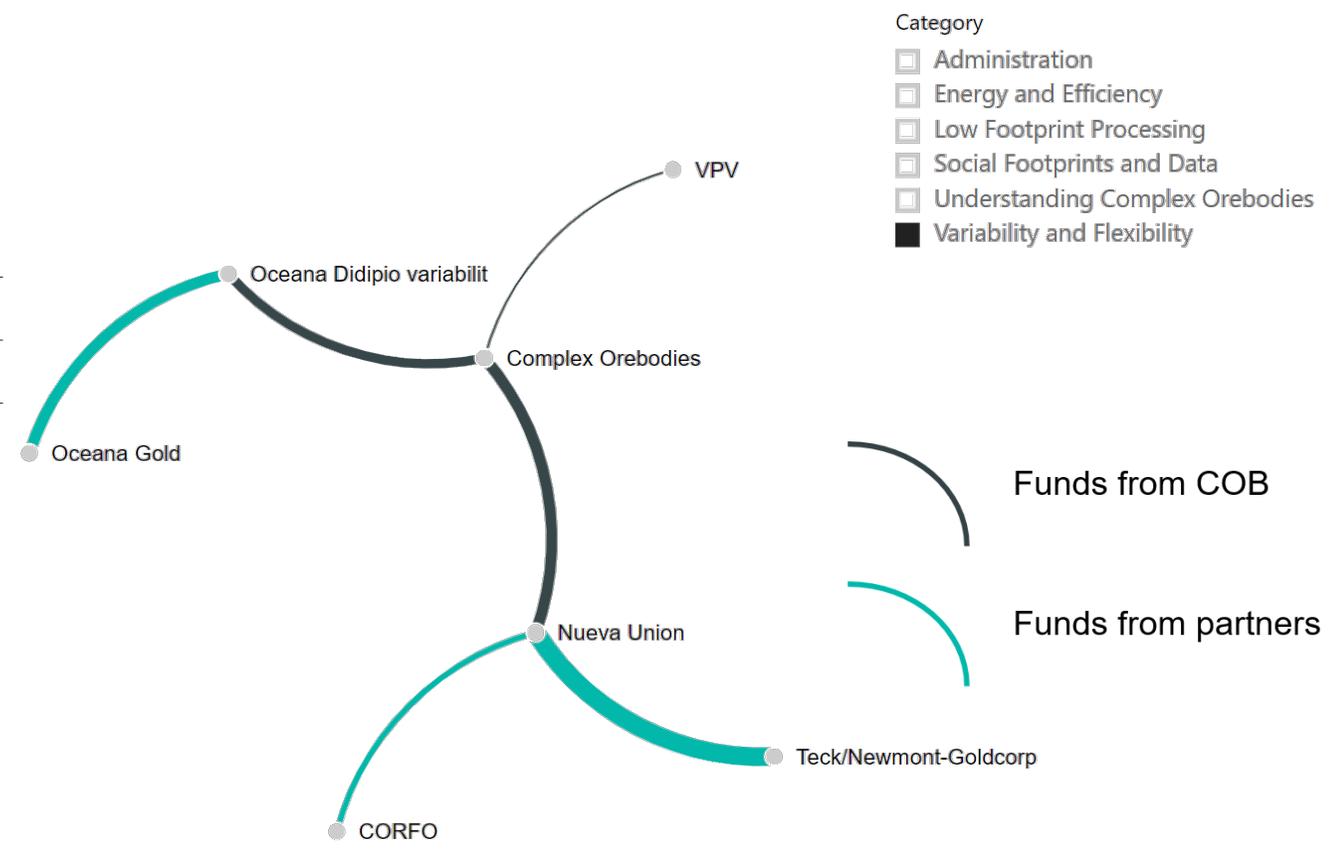
School of Earth and Environmental Sciences

11:30 - 11:50	Wolfram Camp - Mine Wastes	CMLR-BRC	Mansour Edraki
11:50 - 12:10	Savage River OTD Cobalt	BRC-CMLR-SEES	Anita Parbhakar-Fox
12:10 - 12:30	Phytomining Queensland	CMLR-SCE-SEES	Philip Nkrumah
12:30 - 12:50	Regional Water Supplies in Mining Regions	CWIMI-SMIIC	Neil McIntyre or Liliana Pagliero
15:20 - 15:40	Selective Reagents	JKMRC-SCE	Susana Brito e Abreu

Theme 4 - Variability and Flexibility

- Strengthen the feedback loop of deposit definition, mining and processing
- Better understanding of the sources of orebody variability and the flexibility to accommodate it
 - Real-time orebody knowledge
 - Flexible and modular processing
 - Low/zero entry mining

10:10 - 10:30	Variability, Prediction and Visualisation	BRC-JKMRC	Marcin Ziemski, Rick Valenta
10:30 - 10:50	Nueva Union project	BRC-SMIIC	Rocio Vargas



Transformative reduction of energy requirements

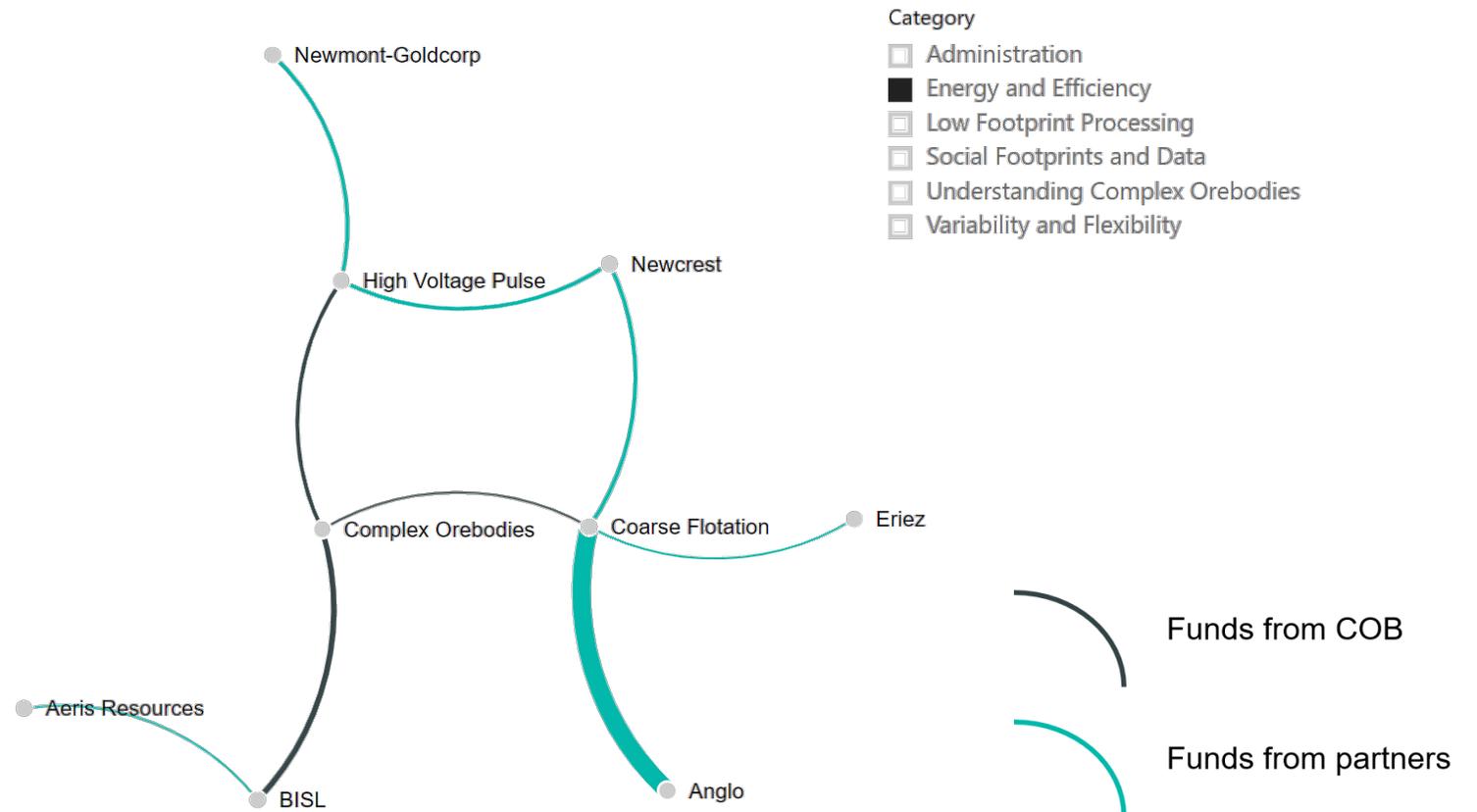
- Pre-treatment (eg HVP)
- Low energy Comminution
- Transformative processing

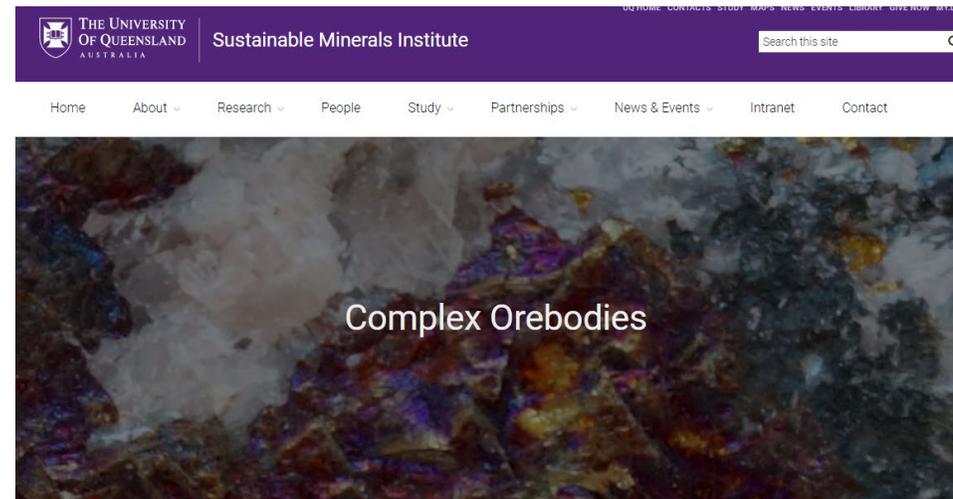
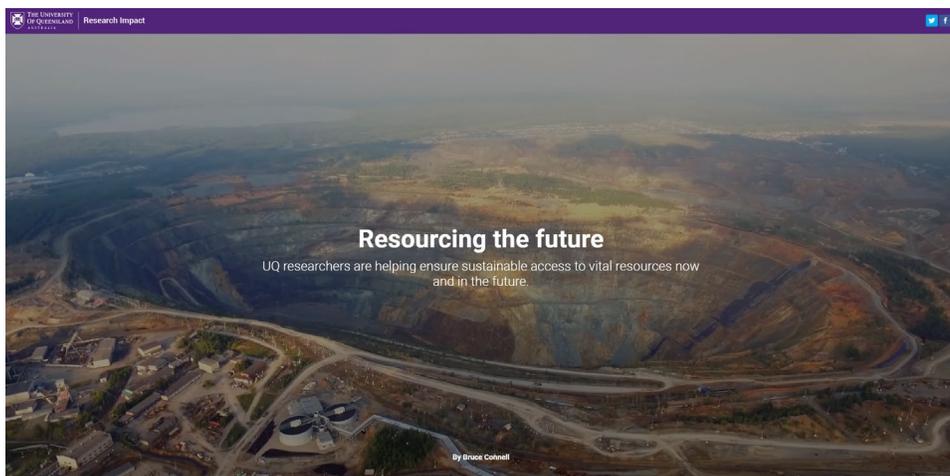
11:10 - 11:30	Bioengineering for In Situ Leach applications	SCMB-SEES-JKMRC	Rob Hoelzle, Marcelo Monteiro, Gary Schenk
15:20 - 15:40	Selective Reagents	JKMRC-SCE	Susana Brito e Abreu
15:40 - 16:00	High Voltage Pulse	JKMRC-BRC-HUST	Frank Shi
16:00 - 16:20	Coarse Particle Flotation	JKMRC-SCE	Kym Runge



School of Chemical Engineering

School of Chemistry & Molecular Biosciences



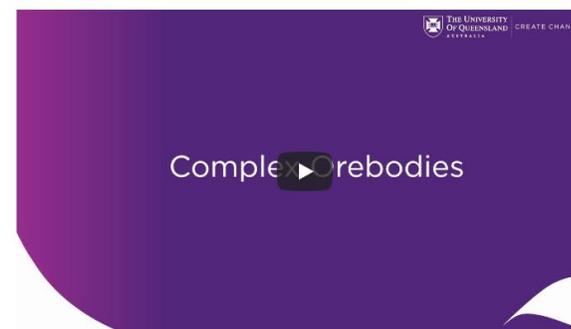


The greatest challenge facing the resources sector is the projected growth in the worldwide demand for raw materials. To meet this, the future supply of raw materials will have to come from a combination of new mine discoveries, recycling, and from undeveloped deposits which have not yet commenced production.

This program focuses on unlocking those deposits or 'Complex Orebodies'.

Extract of interview with Dr Anthony Hodge - Conversations about mining and society

Watch interview in full



Program Leader

[Professor Rick Valenta](#)

Director
W.H. Bryan Mining & Geology Research Centre

Program Leader
Complex Orebodies strategic initiative program

Group Leader - Total Deposit Knowledge
BRC