



THE UNIVERSITY  
OF QUEENSLAND  
AUSTRALIA

CREATE CHANGE

# Selective reagents for COB

## Arsenic Minerals

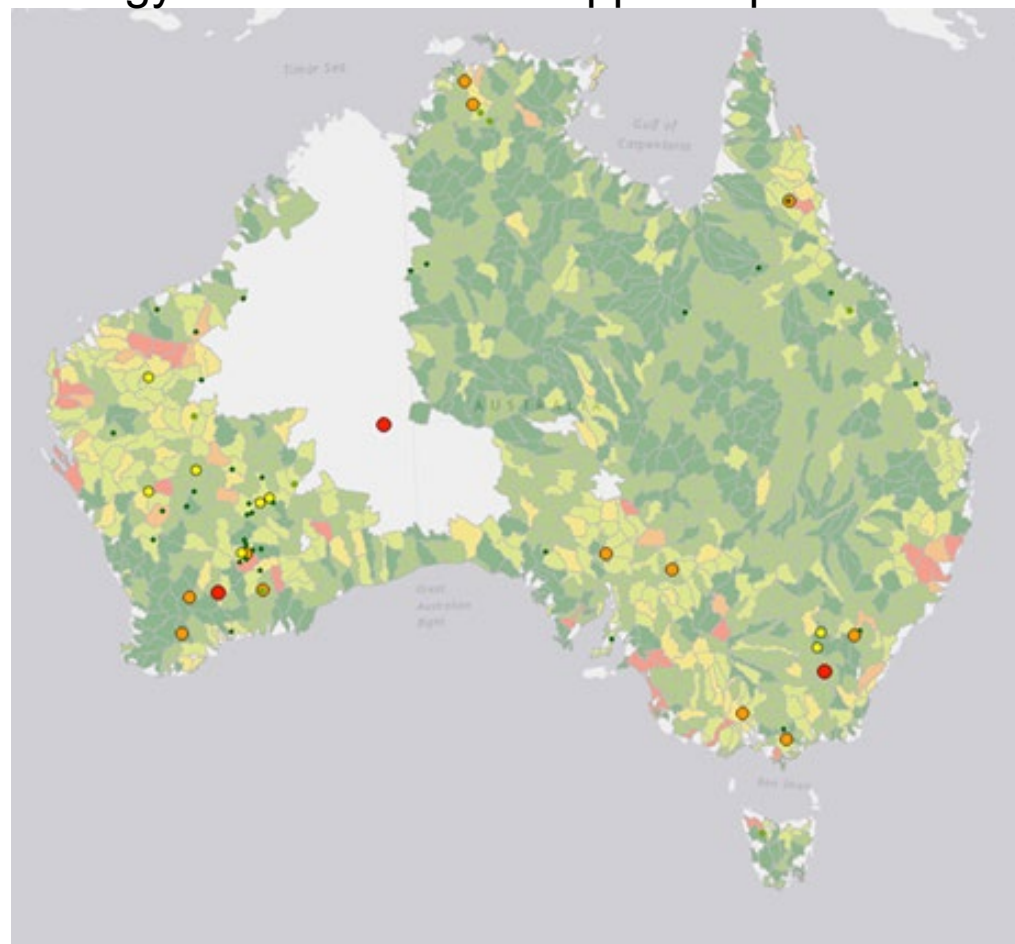
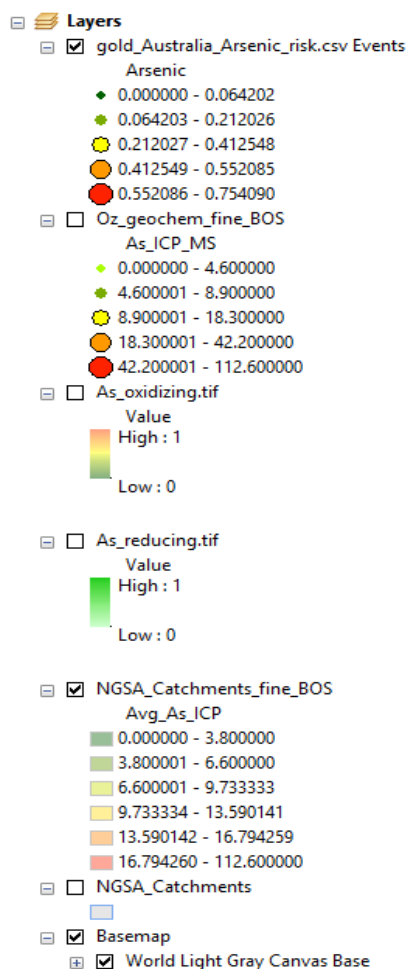
Dr Susana Brito e Abreu | Research Fellow  
JKMRC, SMI

# The problem

- Orebodies amenable to conventional processing are rapidly depleting
- Current need to process ores with lower grades and more complexity, hence, **complex ore bodies are the mines of the future**
- Large number of **deposits currently not mined because it** is not economically or environmentally viable to process the ore
- The world needs development of **innovative technologies** to treat orebodies currently considered untreatable
- As an example, **current reagent chemistries are not effective** at treating some complex orebodies in a sustainable manner, hence, a new generation of reagents for mineral processing is urgently needed

# Undeveloped gold deposits

35/64 deposits present moderate-high risk of arsenic; an analogy can be done for copper deposits.

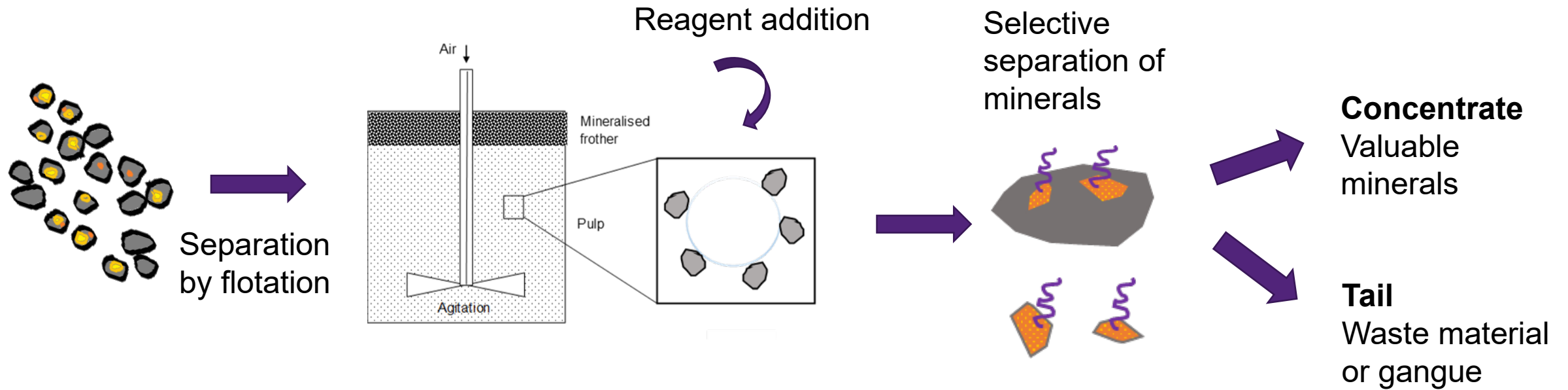


**Fig. 1** – Undeveloped gold deposits with moderate to high risk of arsenic - arsenic in deposits over arsenic in natural soil.

Source: S&P Market Intelligence and National Geochemical Survey of Australia databases (Feb 2019). Thanks to Prof Rick Valenta for producing the map.

➤ During exploration, many potential ore deposits are excluded from processing due to high arsenic concentrations.

# Mineral separation



# Arsenic

- Arsenic minerals are difficult to separate, therefore, arsenic is often recovered together with valuable minerals, contaminating the flotation concentrates.
- Smelters apply financial penalties to concentrates  $> 0.2\%$  As and most smelters cannot process ores if above the limit; except in China where upper limit is  $0.5\%$ .
- Penalties of US\$2.5/tonne per  $0.1\%$  As above the  $0.2\%$  limit. For a typical mine site processing 2000 tph of ore and producing 60 tph of a concentrate with  $0.4\%$  As, the penalty applied will be \$10,150 AUD per day, equivalent to \$3,705,480 AUD per annum.
- As environmental considerations become increasingly important, the acceptable levels will tighten in the future.



Arsenopyrite  
 $\text{FeAsS}$

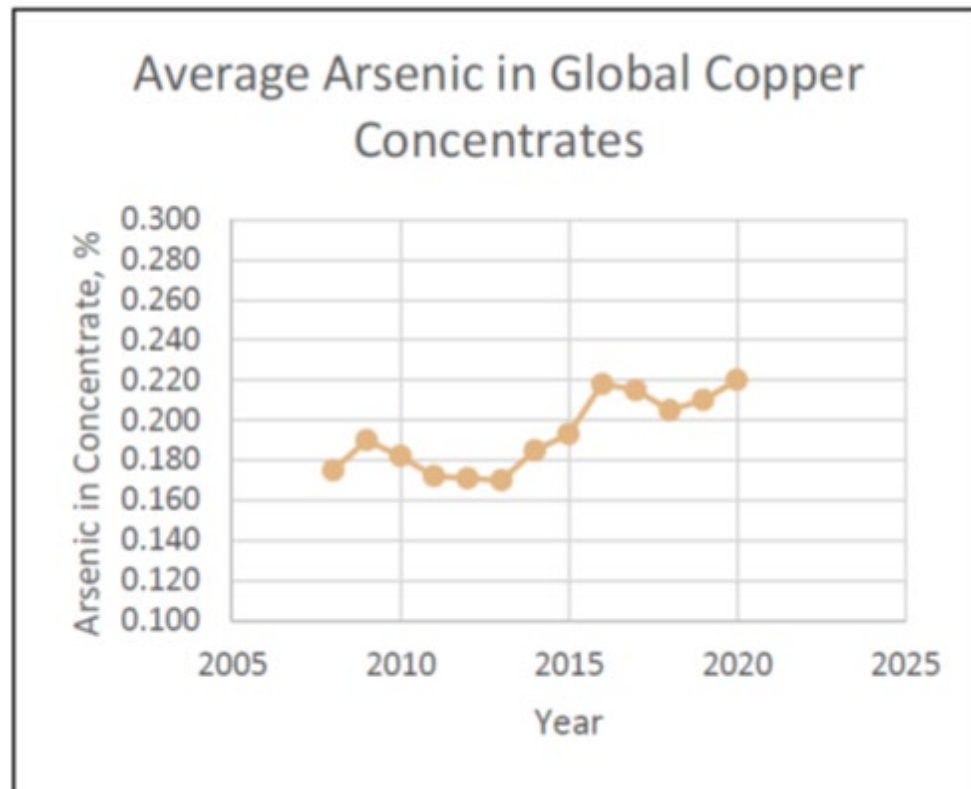


Enargite  
 $\text{Cu}_3\text{AsS}_4$



Tennantite  
 $\text{Cu}_{12}\text{As}_4\text{S}_{13}$

# Arsenic



**Fig. 2** – Expected trend of arsenic levels in copper concentrates worldwide. Reproduced after Baxter (2016).

- As a result of increasing complexity of the ores, the concentration of arsenic in flotation concentrates is expected to increase.
- The current strategy of blending concentrates to achieve acceptable levels of arsenic will not be effective in the future.
- **A step change in the processing of ores is vital**

**A new generation of reagents** for mineral processing is urgently needed, both to achieve sustainable mining and to allow the treatment of currently untreatable orebodies

# Separation of arsenic minerals

- Arsenic minerals exhibit similar flotation behaviour as the non-arsenic counterparts, hence, difficult to separate
- Arsenic minerals that are processed, either end up in the concentrate or tailings
- Arsenic-bearing minerals are economically valuable because they are found associated with copper, gold and silver



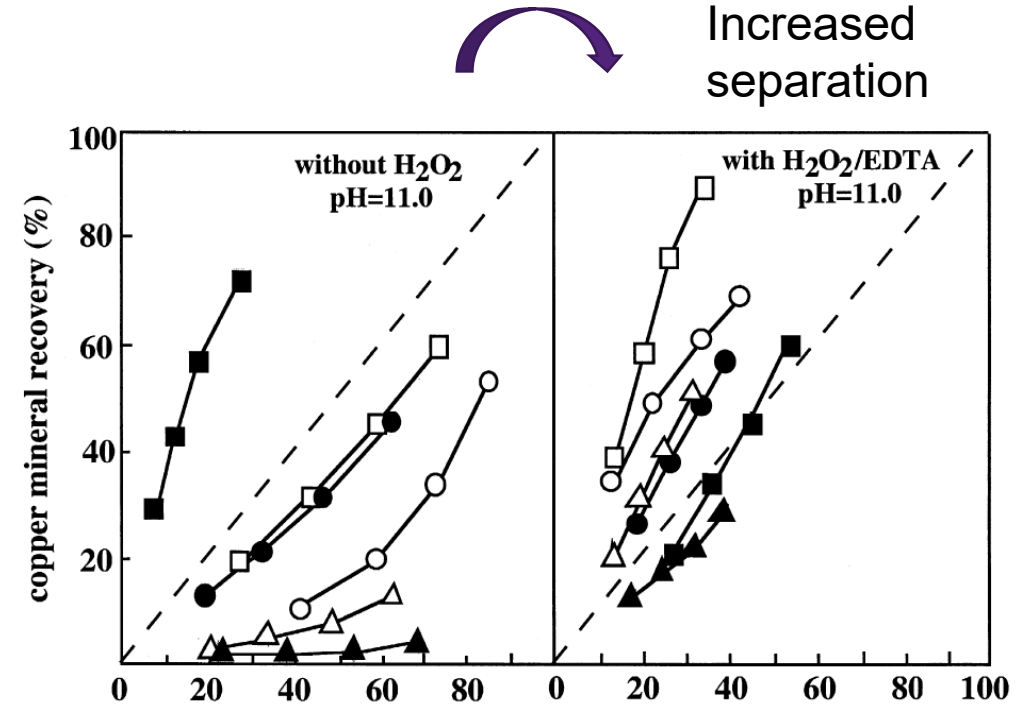
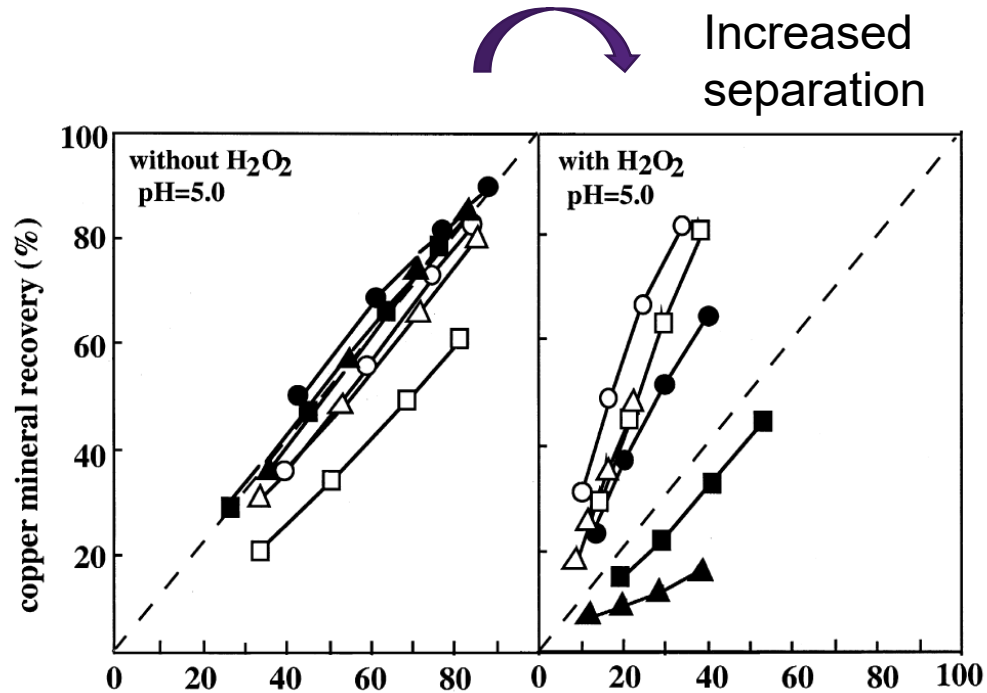
- Selectively recover arsenic minerals present in an ore body in the **early stages** of ore processing, allowing more efficient and safer operation and reduce environmental impact.
- This will open up **new exploration opportunities** by making feasible the exploration of deposits that cannot be treated with the currently available mineral processing technologies



## Separation of arsenic minerals (cont.)

- Separation of copper sulphides (e.g. chalcopyrite) and copper-arsenic bearing sulphides (e.g. enargite, tennantite) is difficult due to similar surface properties and levels of oxidation in the absence of electrochemical control, hence, they have similar floatability (Long et al., 2014; Tayebi-Khorami et al., 2017b)
- Difficult to separate arsenopyrite ( $\text{FeAsS}$ ) from pyrite ( $\text{FeS}_2$ ), as well as enargite ( $\text{Cu}_3\text{AsS}_4$ ) and tennantite ( $\text{Cu}_{12}\text{As}_{14}\text{S}_{13}$ ) from covellite ( $\text{CuS}$ ), chalcocite ( $\text{Cu}_2\text{S}$ ) and chalcopyrite ( $\text{CuFeS}_2$ )
- However, difference in electrochemical properties between these minerals enables some increase in selectivity – however, separation is not absolute and there is a challenge in implementing practical electrochemical control

# Separation by selective oxidation

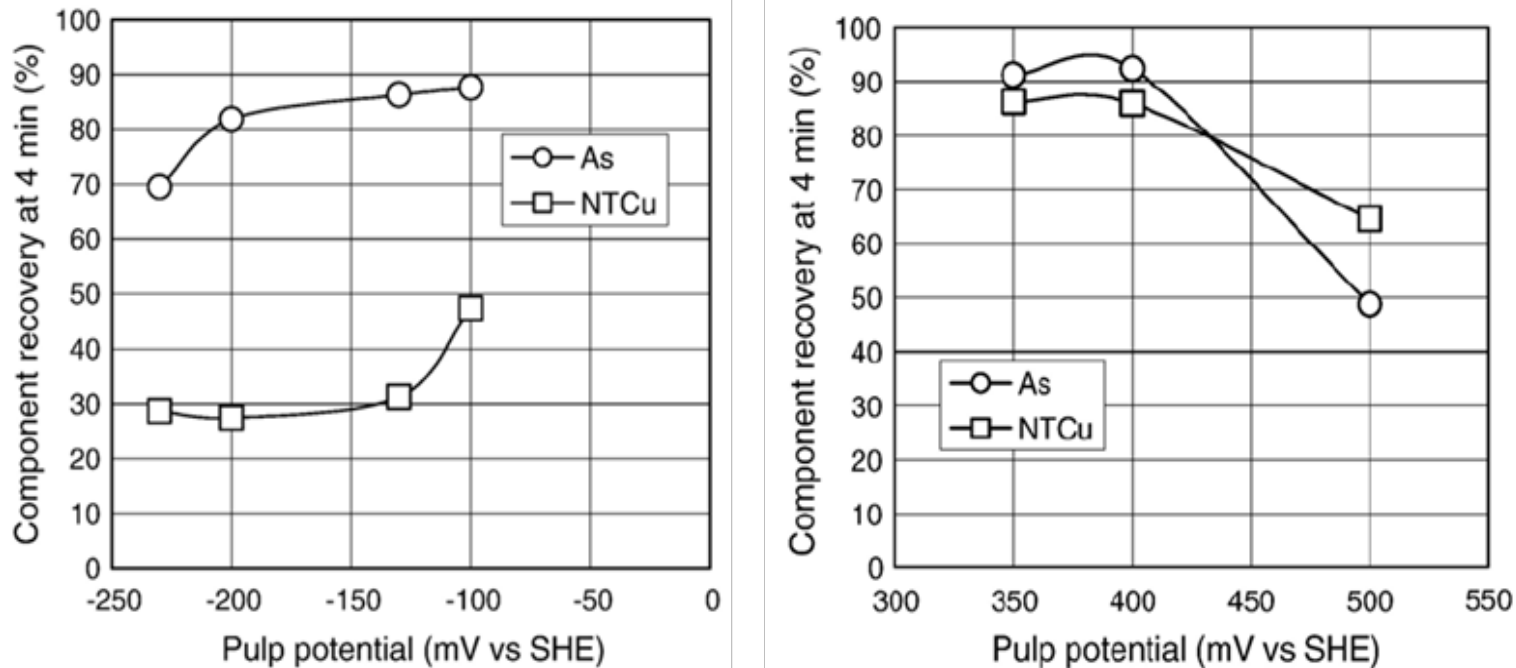


- Chalcocite-energite
- Covellite-energite
- △ Chalcopyrite-energite
- Chalcocite-tennantite
- Covellite-tennantite
- ▲ Chalcopyrite-tennantite

➤ Arsenic minerals oxidise quicker than the non-arsenic counterparts

**Fig. 3** – Copper mineral recovery for copper mineral systems: chalcocite, covellite and chalcopyrite with energite and tennantite. Reproduced from Fornasiero, Fullston & Ralston, 2001.

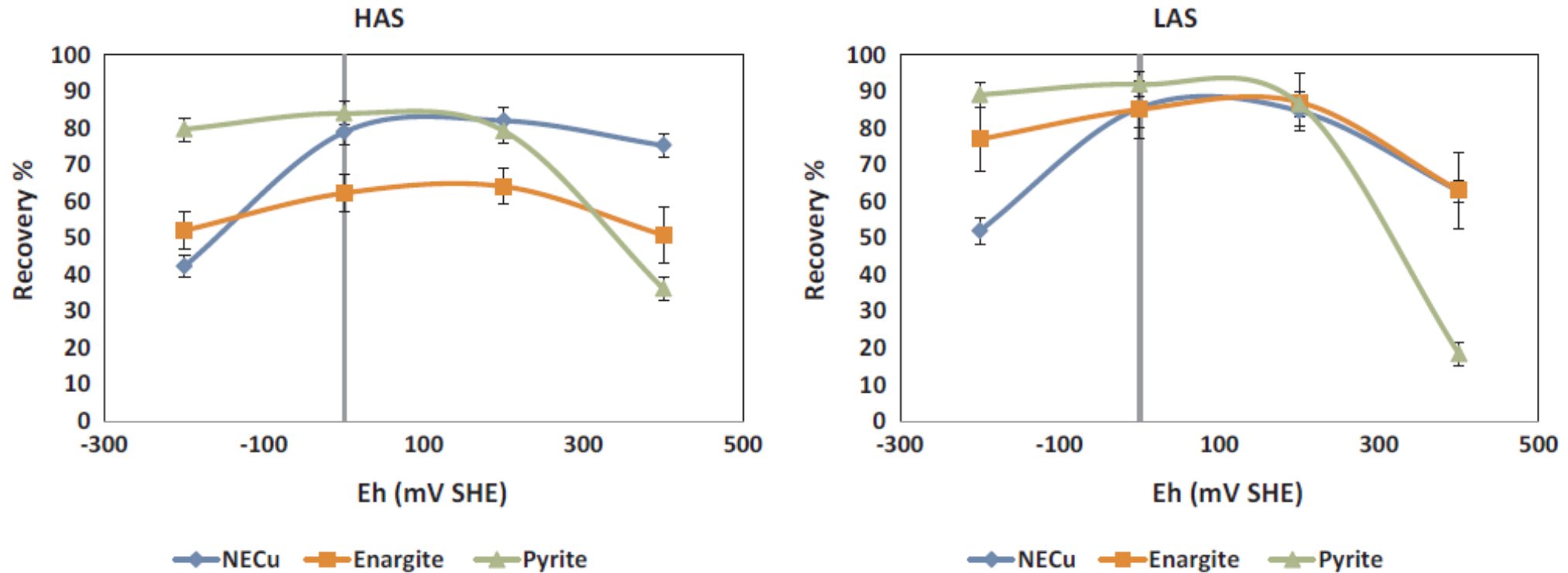
# Separation by electrochemical control



➤ Flotation under reducing pulp potential enables separation of the two minerals, to some degree

**Fig. 4** - Recovery of arsenic tennantite and non-tennantite copper (NTCu) after 4min flotation as a function of pulp potential (pH 12). Reducing conditions (left) and oxidising conditions (right). Reproduced from Smith and Bruckard, 2007.

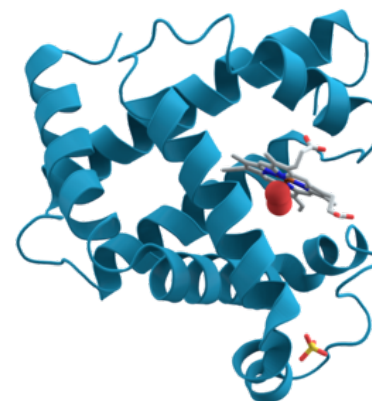
# Separation by electrochemical control (cont.)



**Fig. 5** - Overall recovery of liberated non-enargite copper (NECu), enargite, and pyrite at different Eh conditions. HAS (left) and LAS (right) concentrates from Tampakan ore. Reproduced from Tayebi-Khorami et al., 2017.

# Opportunities

- **More research** is required for better understanding of the fundamental mechanisms and practical implications
- **New technologies** are required for more effective separation, envisaged through novel selective reagents
- Advances in nanobiotechnologies may be key to creating a step change in **reagent technologies**



Current reagents	New reagents
Non-selective	Selective
Toxic	Non-toxic
Adverse environmental impact	Reduced environmental impact

# Research direction

## ➤ Current

- Initial studies into the application of nanobiotechnologies in mineral separation with a focus on arsenic, in collaboration with AIBN (UQ ECR Grant 2019)

## ➤ Starting January 2020

- Newcrest-funded PhD project on novel reagents for arsenic minerals
- ARC Centre of Excellence for Enabling Eco-Efficient Beneficiation of Minerals



THE UNIVERSITY  
OF QUEENSLAND  
AUSTRALIA

CREATE CHANGE

# Thank you

Dr Susana Brito e Abreu | Research Fellow  
JKMRC, SMI  
[s.britoabreu@uq.edu.au](mailto:s.britoabreu@uq.edu.au)  
07 3346 5934