

# Skorpion Zinc: Mine-to-metal zinc production *via* solvent extraction

Kathy Sole

Anglo Research, South Africa

Herman Fuls, Jürgen Gnoinski

Skorpion Zinc, Namibia

# Traditional Zinc Processing

- Usually present as sulphide
  - Amenable to upgrading
  - Roast-Leach-Electrowin process
- Oxides and silicates considered “untreatable”

# Skorpion Zinc

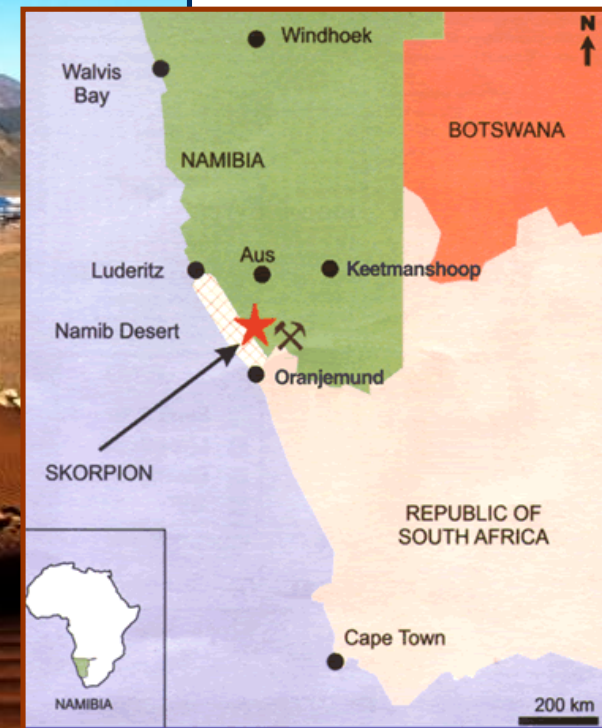
Oxide/silicate:	Zn	10 - 40%
	Si	26%
	Fe	2 - 3%
	Some Cl and F	

- First application of Zn SX to primary processing
- Silicate leaching technology
- First metal May 2003
- 150 000 t/a SHG zinc (>99.995% purity)

# Overview

- Electrolyte requirements for Zn EW
- Skorpion Zinc flowsheet
- Challenges and process improvements during first 5 years of operation
- Comparison of design and actual performance

# Skorpion Zinc



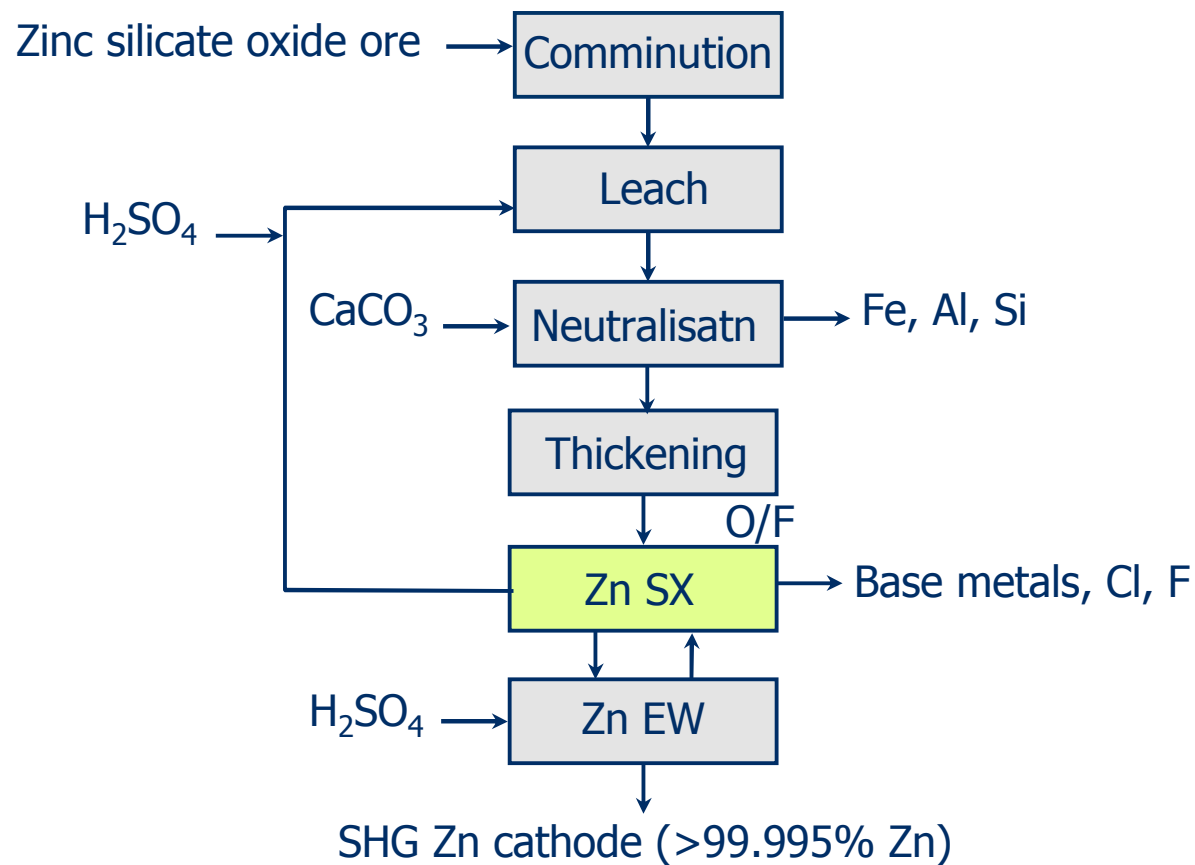
# Skorpion Zinc



# Advance Electrolyte Specification

Element	Concentration (mg/l)	Element	Concentration (µg/l)
Zn	> 90 000	Ga	3
Mn	2 000	Ge	< 10
Cd	< 0.05	As	< 10
Co	< 0.05	Sn	< 1
Ni	< 0.05	Sb	< 1
Fe	< 5	Te	< 1
Cl	< 0.1	Tl	25
F	< 0.02		

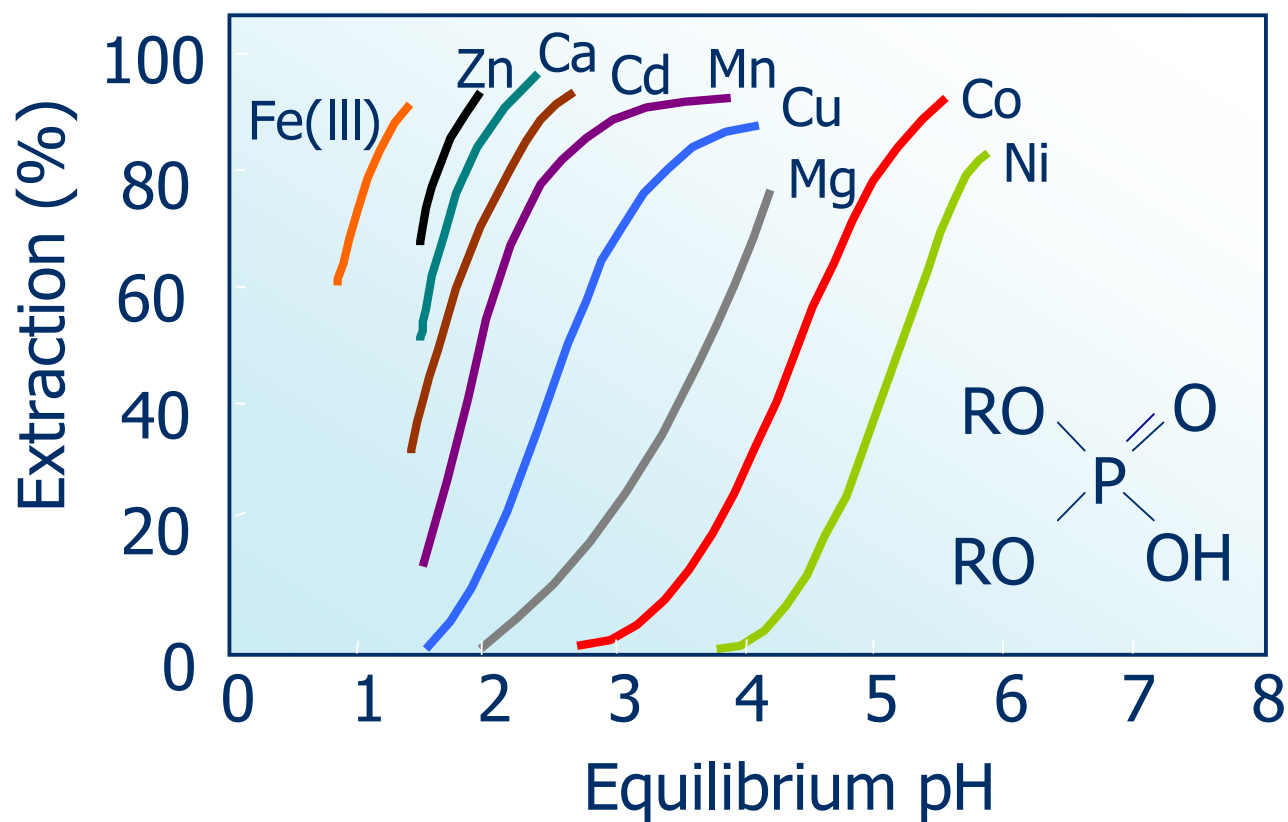
# Simplified Skorpion Flowsheet



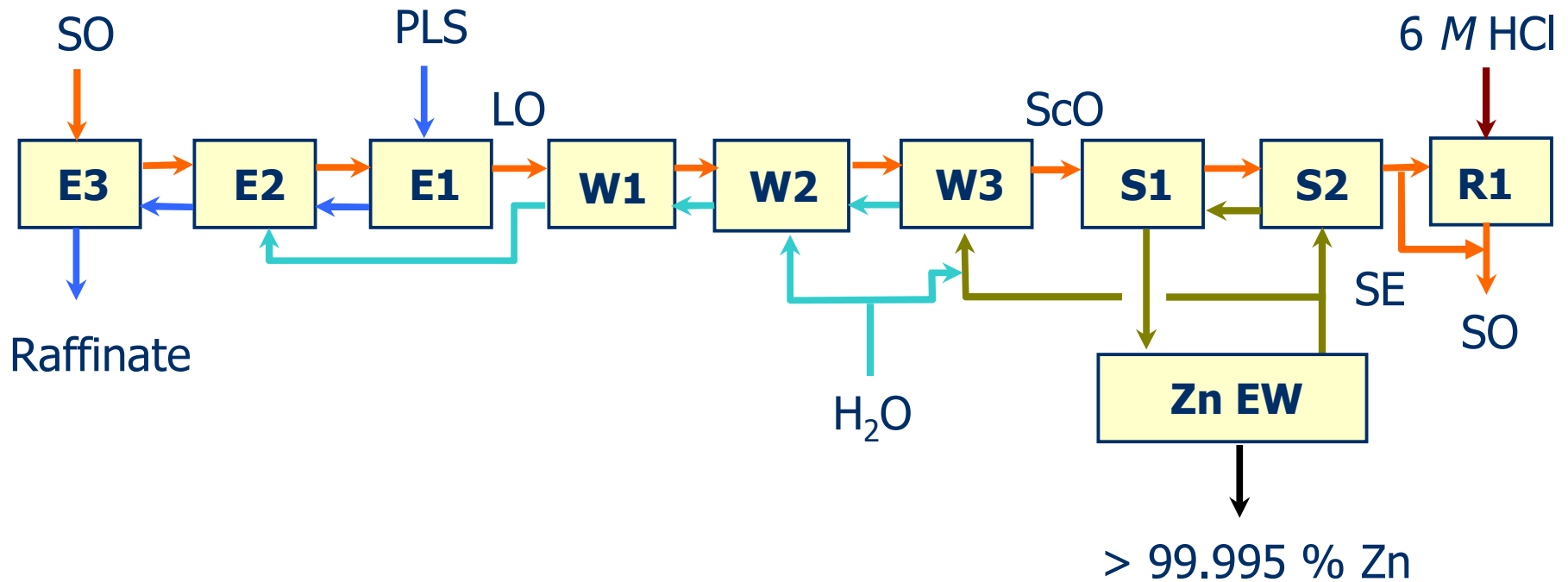
# Silicate Leaching

- High SiO<sub>2</sub> in ore
  - Avoid conditions for silica gel formation
  - Minimise Zn losses in filtration
- dilute leach liquor (30 g/L Zn)
- upgrade and purify by SX

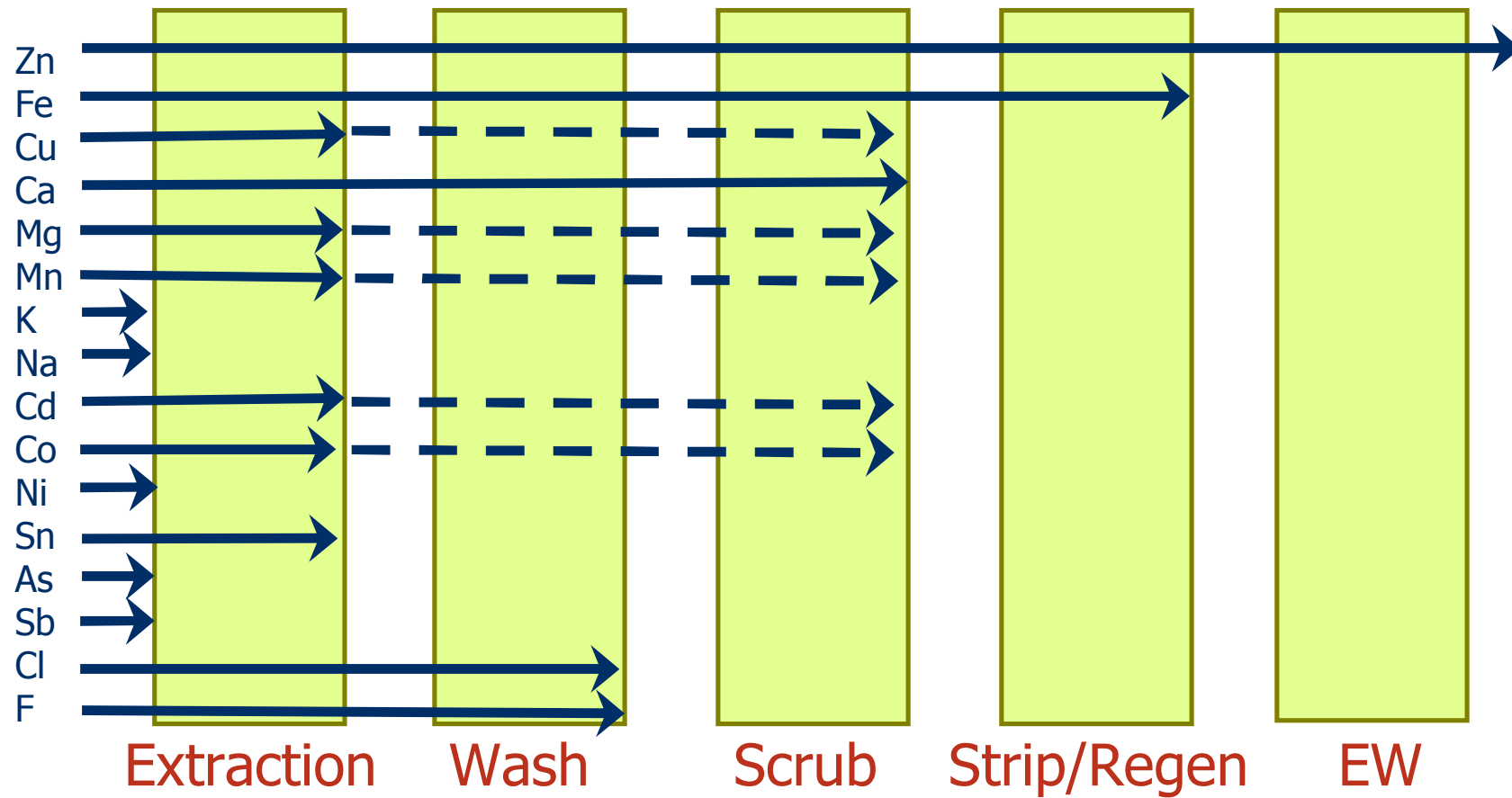
# Zn Extraction by D2EHPA



# Skorpion Zn SX Circuit



# Selectivity of SX



*From Técnicas Reunidas*

# Full-Scale SX Process Performance

Element	Specification for AE (mg/l)	Skorpion electrolyte (mg/l)
Zn	> 90 000	~ 120 000
Cd	< 0.05	0.012
Fe	< 5	< 5
Mn	< 3000	2500
Co	< 0.05	<b>0.07</b>
Ni	< 0.05	<b>0.07</b>
Ca	—	~ 50
Cl	< 100	56
F	< 20	3

# Full-Scale SX Process Performance

- Selectivity matches theory
- Capacity exceeds design — 107 % Zn transfer

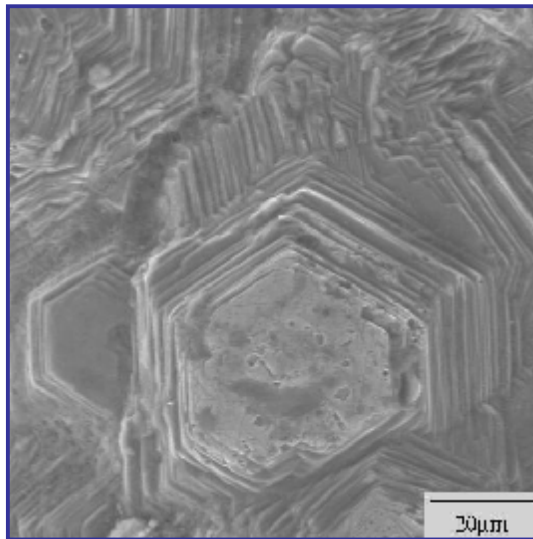


# Challenges

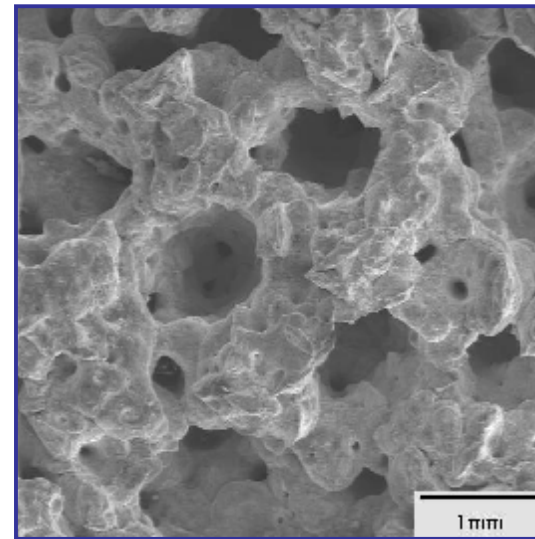
- Organic transfer to EW
- Solids in PLS
- Health of organic phase
- Fire risk – single stream: 100% production loss

# Process Improvements

## Minimisation of organic transfer to EW



No D2EHPA



5 mg/L D2EHPA

# Process Improvements

## Minimisation of organic transfer to EW

Advance electrolyte processed through

- aftersettler
- flotation column
- activated carbon filter/coalescers  
(lead-lag configuration)

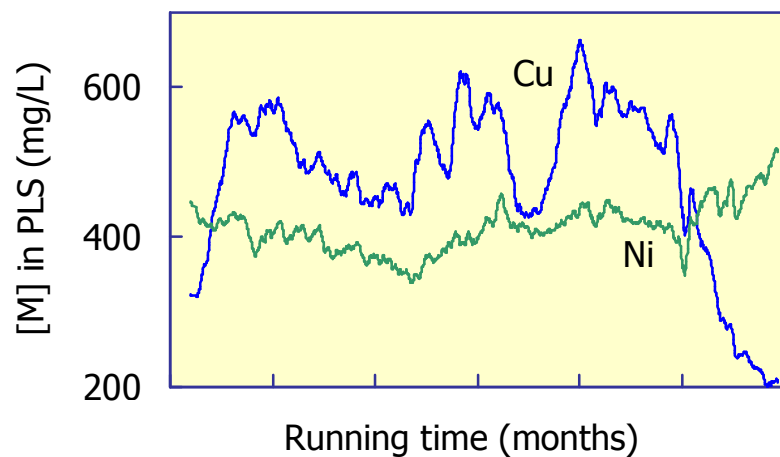
→ < 1 mg/L OE



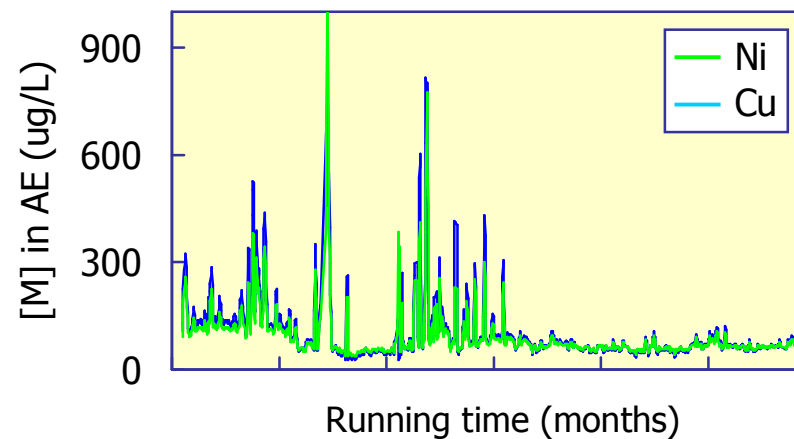
# Process Improvements

## Department of impurities to electrolyte

### SX Feed



### Advance electrolyte



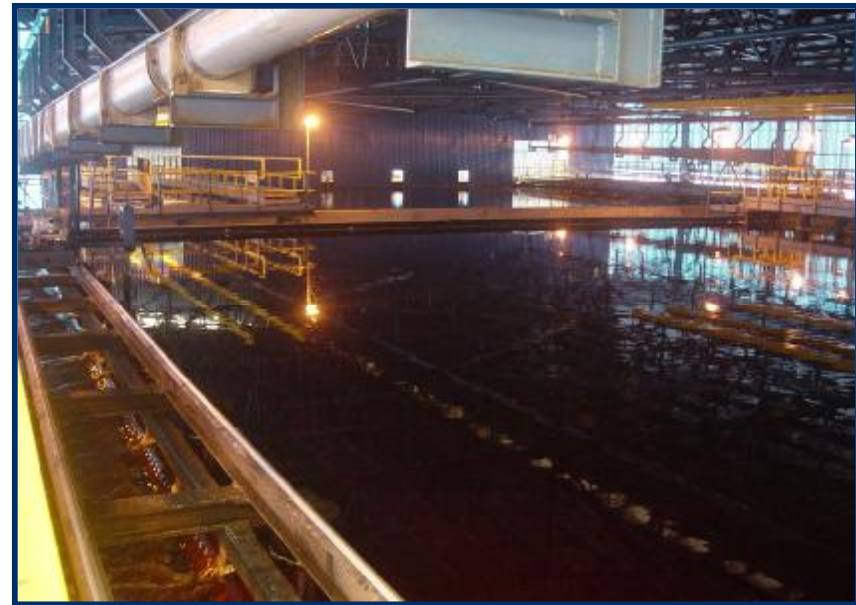
# Electrowinning of Zinc

Half-cell reduction	$E^{\circ}$ (V)
$\text{Cu}^{2+} + 2 e \rightarrow \text{Cu}$	0.34
$2 \text{H}^{+} + 2 e \rightarrow \text{H}_2$	0.00
$\text{Ni}^{2+} + 2 e \rightarrow \text{Ni}$	-0.26
$\text{Co}^{2+} + 2 e \rightarrow \text{Co}$	-0.28
$\text{PbSO}_4 + 2 e \rightarrow \text{Pb} + \text{SO}_4^{2-}$	-0.35
$\text{Cd}^{2+} + 2 e \rightarrow \text{Cd}$	-0.40
$\text{Zn}^{2+} + 2 e \rightarrow \text{Zn}$	-0.76
$\text{Mn}^{2+} + 2 e \rightarrow \text{Mn}$	-1.18

# Process Improvements

## Department of impurities to electrolyte

- Solids in PLS  
~100 mg/L TSS (target <10 mg/L TSS)  
excessive crud formation
- Linked to excursions of Ni, Co
- High organic consumption



# Process Improvements

## Control of solids' department to SX

### Original design

- thickener
- clarifier
- sand filters



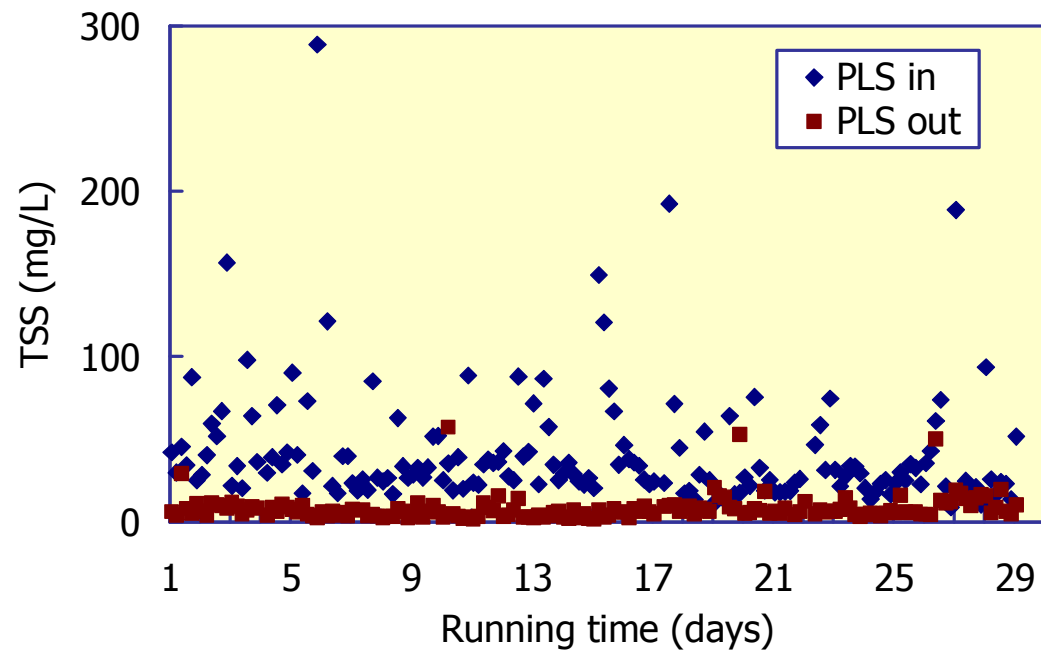
### Process improvements

- PLS ponds
- avoid colloidal silica formation
- pH control of leach
- avoid leach plant downtime
- reduce mixer air entrainment
- Roymec pinned-bed clarifier

# Process Improvements

## Control of solids' department to SX

Pinned-bed clarifier → <10 mg/L TSS



# PLS and Electrolyte Composition

Element	PLS (mg/L)		AE (mg/L)	
	Design	Actual	Design	Actual
Al	300	82		190
Ca	650	660		50
Cd	100	<b>330</b>	<0.05	0.01
Cl	5000	1030	<100	50
Co	100	18	<0.05	0.02
Cu	700	500	<0.05	<b>0.09</b>
F	200	40	<20	7
Fe	5	1.5	<5	<5
Mg	200	<b>1040</b>		
Mn	500	<b>2120</b>	3000	2200
Ni	800	330	<0.05	<b>0.08</b>
Si	40	<b>70</b>		
Zn	30 000	<b>38 000</b>	90 000	<b>117 000</b>

# Advantages of Zn SX

- High Si in ore
  - Dilute leach solution to avoid silica gel
  - Minimise soluble zinc losses in filtrate



# Advantages of Zn SX

- High Si in ore
- EW very sensitive to impurities
  - Reject Cu, Ni, Co, Cd, Mn, Mg
  - Reject F, Cl
  - Reject Ca



## Advantages of Zn SX

- High Si in ore
- EW very sensitive to impurities
- Upgrade
  - 30 g/l Zn in PLS
  - > 100 g/l Zn in AE



## Advantages of Zn SX

- High Si in ore
- EW very sensitive to impurities
- Upgrade
- SHG Zn
  - > 99.995 % purity



## SHG Zinc Cathode

Element	SHG spec.* (ppm)	Skorpion (ppm)
Cd	30	0
Cu	10	7
Fe	20	3
Pb	30	25
Sn	2	2
Zn	999950	999963

\* British standard, 1996

# Product Quality



150 000 t/a

>99.995% Zn

SHG Zn



# Conclusions

- Breakthrough technology for zinc oxide treatment – “untreatable” ore
- First mine-to-metal operation
- Robust technology
- SX process considered a technical success
- Consistent production of 150 000 t/a SHG Zn
- Amongst world’s highest quality and lowest cost zinc producers (2007 C1 US¢ 32/lb Zn)

# Acknowledgements

Skorpion Zinc  
Anglo Base Metals



Sole 2001, Proceedings 6<sup>th</sup> World Congress Chemical Engineering, Melbourne

Fuls *et al.* 2005, Proceedings ISEC 2005, Beijing

Gnoinski *et al.* 2005, Proceedings Lead-Zinc 2005, Osaka

Sole *et al.* 2008, Proceedings ISEC 2008, Tucson, AZ